ENGINEERING

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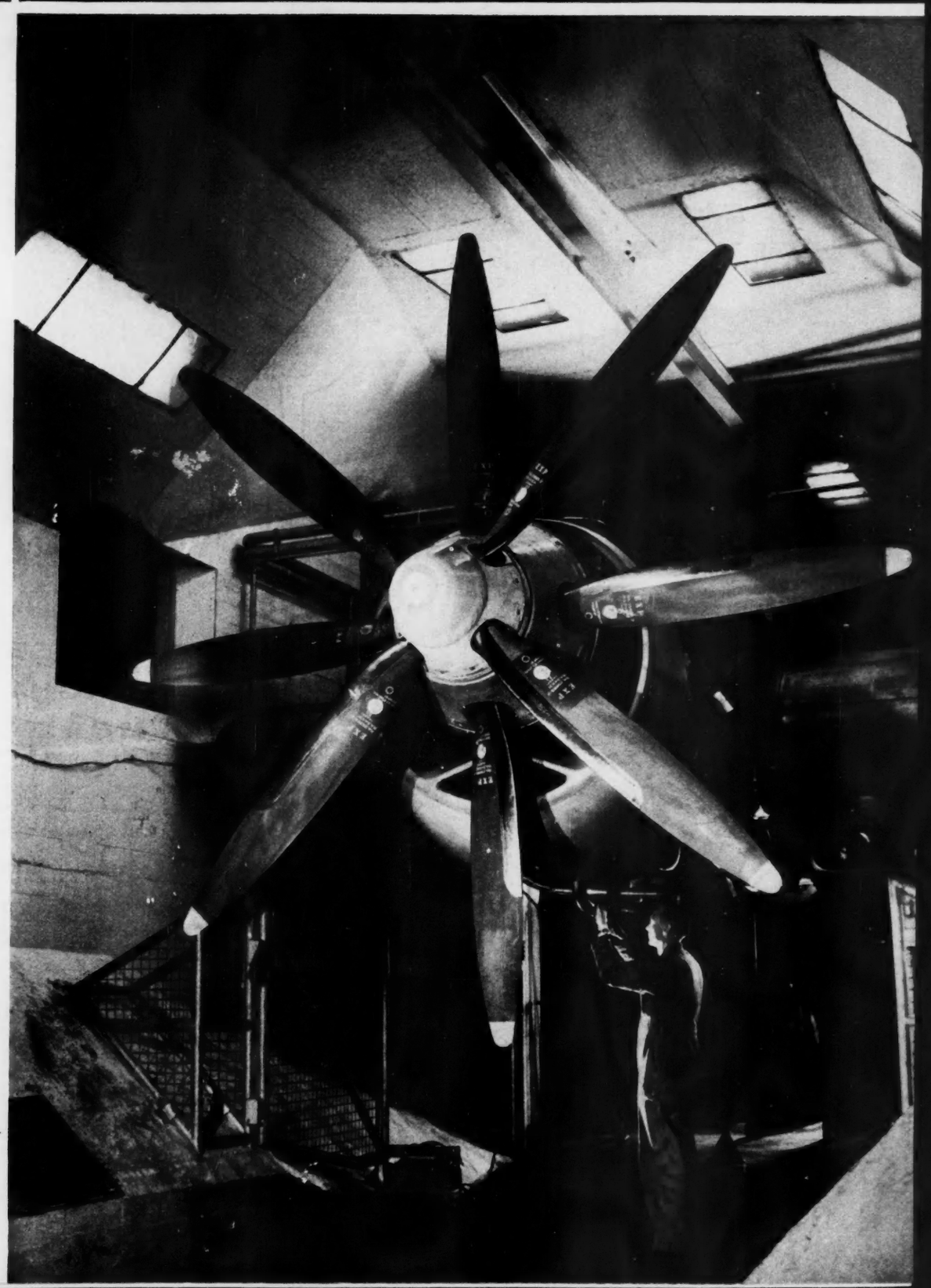
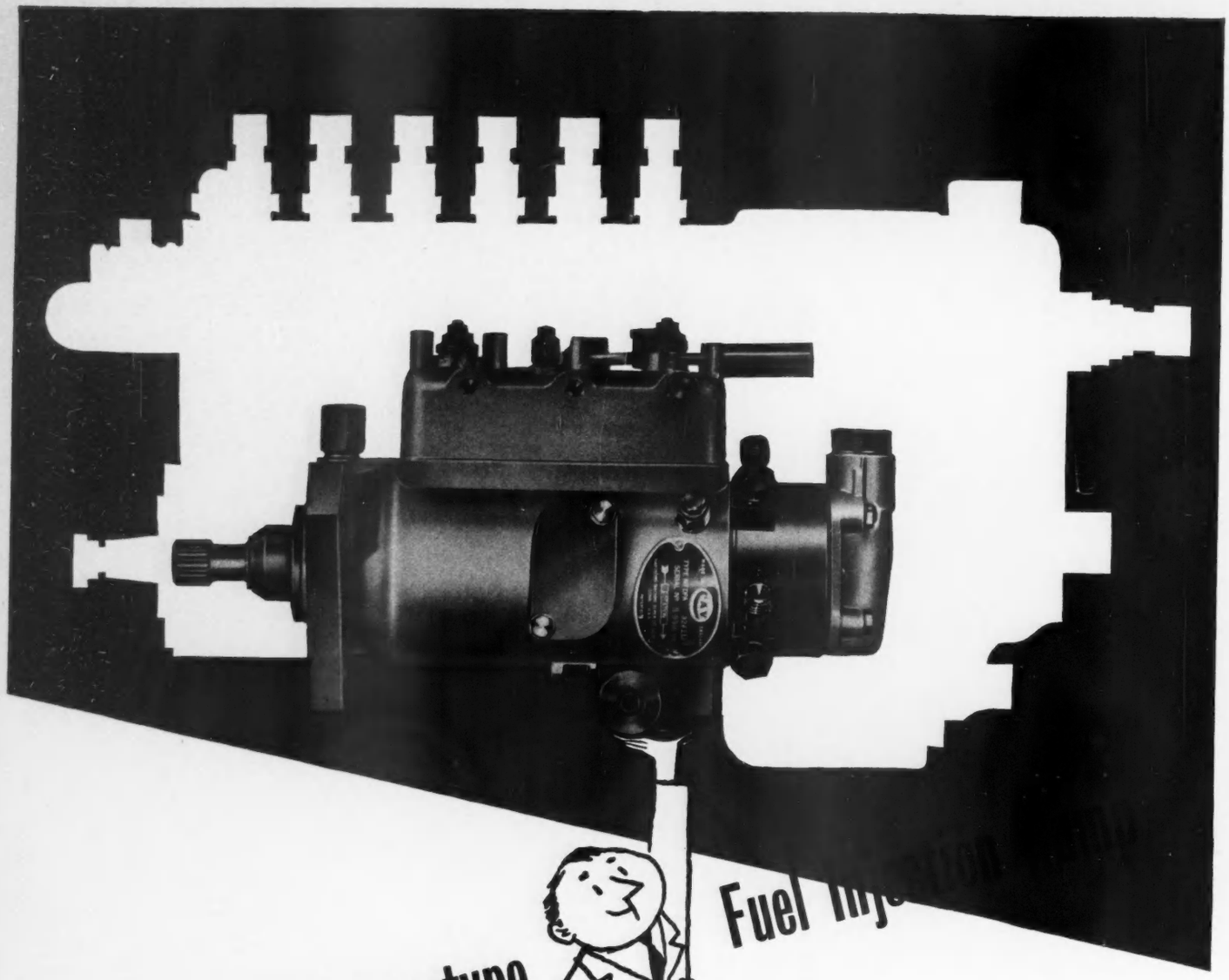


Engine under Test



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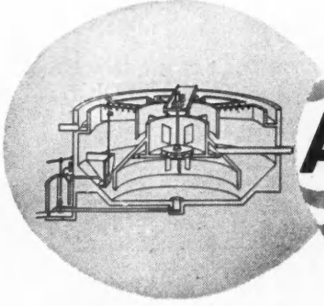

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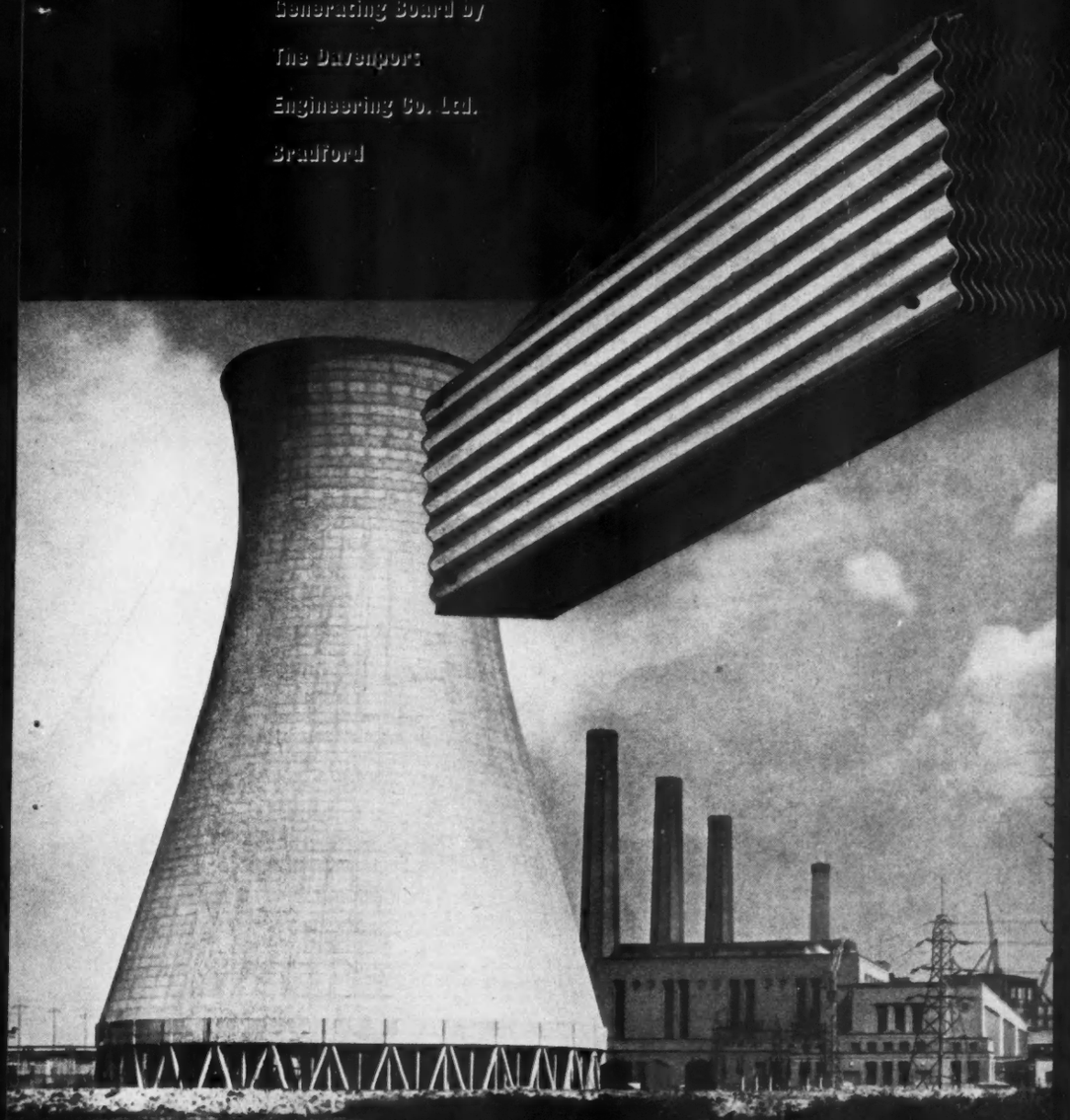

a) Positioning a cooling pack.

b) "EVERITE" asbestos cement pressure pipes with eliminator packs above.

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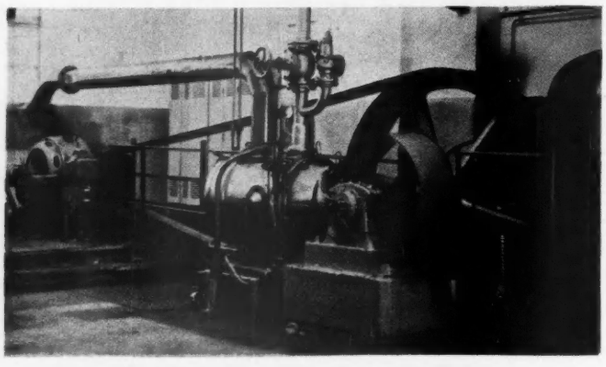
With companies or agents in ninety countries, Atlas Copco is the world's largest organisation specialising solely in compressed air equipment. Products include stationary and portable compressors, rock drills, loaders, hoists, air tools and paint-spraying equipment. Wherever you are, the international Atlas Copco group offers expert advice and provides a complete after-sales service.



Built to last! This Atlas Copco compressor was installed at the Bofors engineering works (Sweden) in 1907. It is still in operation

WRITE FOR THE LEAFLET

Leaflet E1127 gives full details of the ER6 compressor. Write for a copy to your local Atlas Copco company or agent or to the address below.

Atlas Copco puts compressed air to work for the world

Atlas Copco AB, Stockholm 1, Sweden. In the U.K. Atlas Copco (Great Britain) Ltd., Hemel Hempstead, Herts.

22 April 1960

Vol. 189 No. 4905

Founded in 1866

ENGINEERING

PUBLISHED EVERY FRIDAY

36 Bedford Street London WC2 England Telephone: Temple Bar 3663

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Cover Picture

A Double Mamba turbo-prop on test. The engine comprises two gas-turbines side-by-side, each driving one of a pair of coaxial counter-rotating propellers through reduction gearing. Each turbine can be operated independently for overall economic working. (*Nurnberg photograph for* ENGINEERING.)

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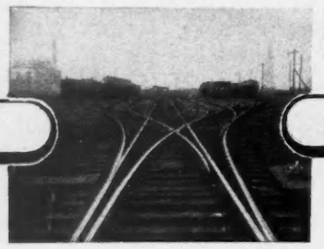

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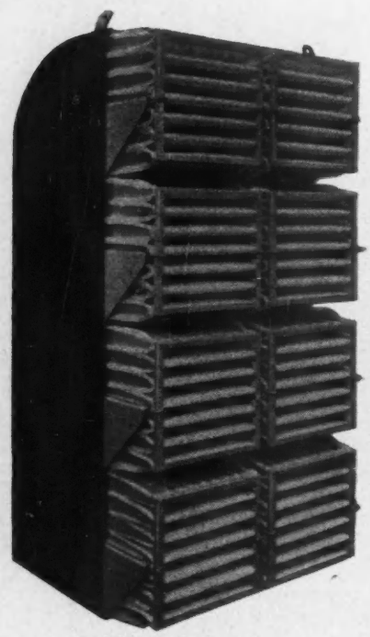

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The lectures will deal with (*a*) the heat transfer and friction power relationships for heat transfer surfaces with special reference to high performance extended surfaces, and (*b*) recent developments in heat surfaces.

Fee for the Course, 10s.

Enrolment can be effected by personal attendance at the College or by application for an enrolment card. B 821

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A COURSE OF LECTURES illustrated by films, on "FUNDAMENTALS OF LUBRICATION," will be given by Dr. W. DAVEY, B.Sc., F.R.I.C., A.M.Inst.Pet., on Wednesday evenings at 6.30 p.m., commencing 27th April, 1960. Fee for the course two guineas.

Enrolment form and further details from the REGISTRAR. B 848

THE COLLEGE OF AERONAUTICS

ONE YEAR POST-GRADUATE COURSE IN FLIGHT CONTROL

1960-61

Applications are invited for the one year course in FLIGHT CONTROL which begins on 10th October, 1960. Prospective students must be of graduate status in an appropriate branch of science or engineering, or have attended a preliminary one year course at the College and, preferably, have had practical experience.

The purpose of the course is to give instruction in the techniques employed in the automatic control of all types of flying machine.

Students who complete the course satisfactorily will be awarded the Diploma in Advanced Engineering (D.A.E.).

Further information and forms of application may be obtained from the WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. B 624

THE COLLEGE OF AERONAUTICS

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1960-1961

Applications are invited for the one year course in CONTROL ENGINEERING which begins on 10th October, 1960. Prospective students must be of graduate status in an appropriate branch of science or engineering, or have attended a preliminary one year course at the College, and preferably, have had practical experience.

The purpose of the course is to give instruction in the techniques employed in control engineering as applied in a wide range of industries.

Students who complete the course satisfactorily will be awarded the Diploma in Advanced Engineering (D.A.E.).

Further information and forms of application may be obtained from the WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. B 623

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A COURSE OF LECTURES ON PROBLEMS IN HYPERSONIC AERODYNAMICS

will be given at the College from MONDAY, 2nd MAY TO FRIDAY, 13th MAY, 1960.

The course is intended for aerodynamicists, physicists and research workers who require a working knowledge of hypersonic aerodynamics. A knowledge of subsonic and supersonic aerodynamics and of mathematics up to degree level is desirable.

FEES for the course are:—

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Residence Charge (including full board) 10 guineas

Forms of enrolment and copies of the syllabus may be obtained from the WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. B 607

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DEPARTMENT OF MATHEMATICS

The next **SANDWICH COURSE IN APPLICABLE MATHEMATICS** (of four years' duration) will begin in September, 1960. The course is recognised for the award of the Diploma in Technology. State Scholarships, Technical State Scholarships, and Local Education Authority awards may be held by students attending this course.

Enquiries are invited from students and also from industrial organisations, schools and further education establishments which may wish to recommend students for the course.

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TENDERS are invited for the construction of 1.7 miles of new dual carriageway and improvement of existing carriageway between Drome Corner, Sealand, and Queensferry (including ancillary drainage works) and the construction of a 410 ft. three span bridge over the River Dee.

Tender documents and drawings may be obtained from E. W. W. RICHARDS, ESQ., A.M.I.C.E., A.M.I.Struct.E., A.M.I.Mun.E., COUNTY SURVEYOR AND BRIDGEMASTER, COUNTY BUILDINGS, MOLD, on or after 2nd May, 1960, on payment of a deposit of £25, returnable on receipt of a bona fide tender.

Tenders endorsed "Queensferry Bridge and By-Pass" to be returned to the undersigned by 15th June, 1960.

The Council does not bind itself to accept the lowest or any tender.

W. HUGH JONES,
CLERK OF THE COUNTY COUNCIL.
COUNTY BUILDINGS,
MOLD,
FLINTSHIRE. B 786

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MARLOW SUSPENSION BRIDGE STRENGTHENING

THE BUCKS COUNTY COUNCIL intend to invite **TENDERS** in the autumn of this year for strengthening Marlow Suspension Bridge including renewing the suspension chains and deck while maintaining traffic crossing the bridge.

Contractors wishing to be invited to tender for the above works are asked to submit particulars of their experience in carrying out bridgeworks of a similar nature and produce evidence of ability to execute such works piecemeal with minimum interference to vehicular traffic crossing the bridge continuously in single line working.

Particulars to be sent to the COUNTY SURVEYOR, COUNTY OFFICES, AYLESBURY, BUCKS, not later than Thursday, 12th May, 1960. B 856

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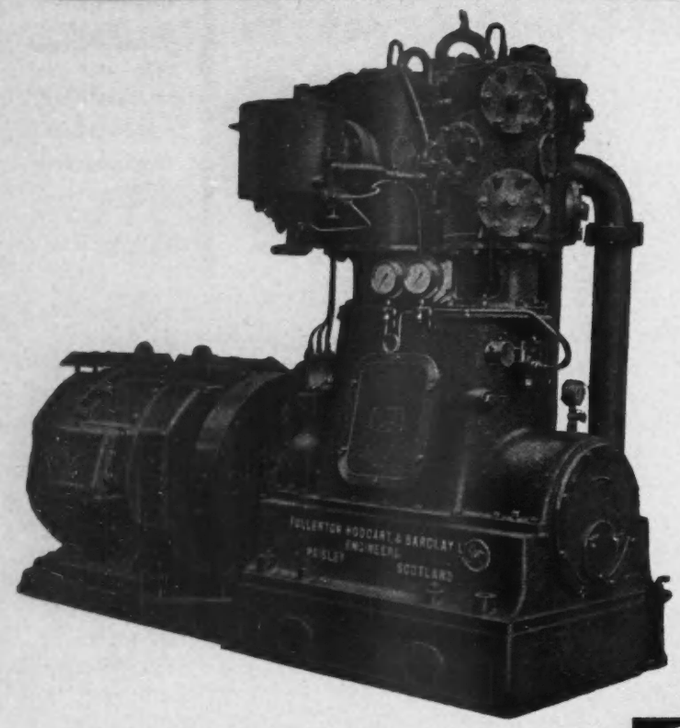

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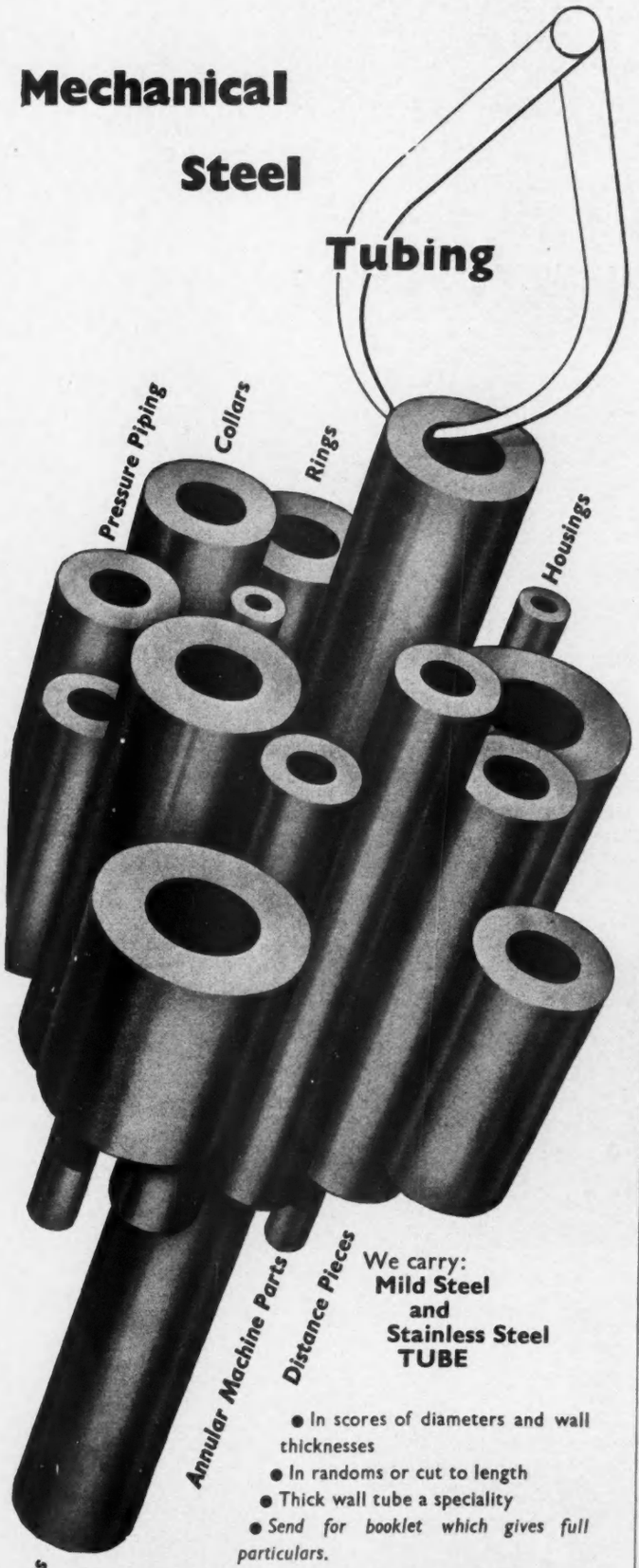

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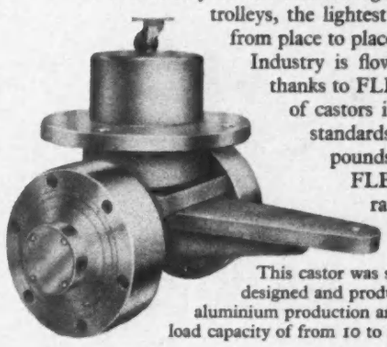

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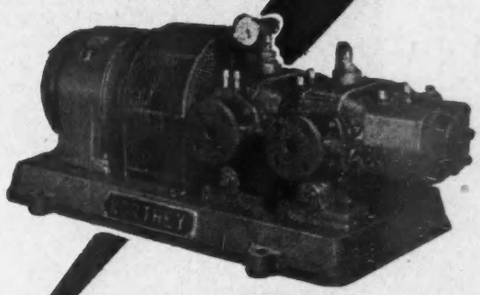

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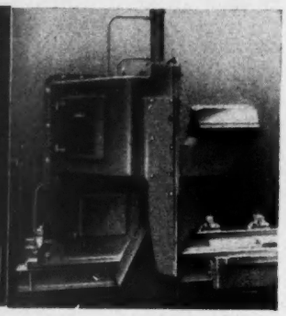

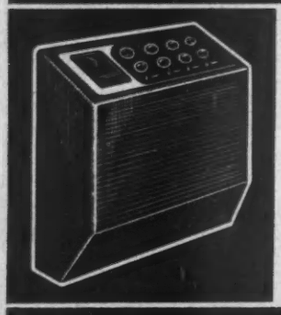

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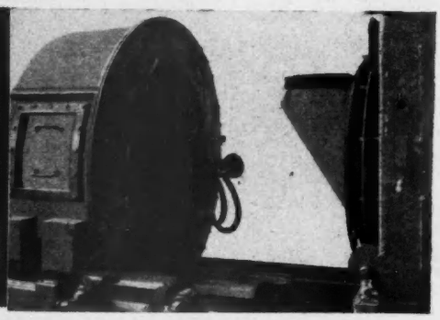

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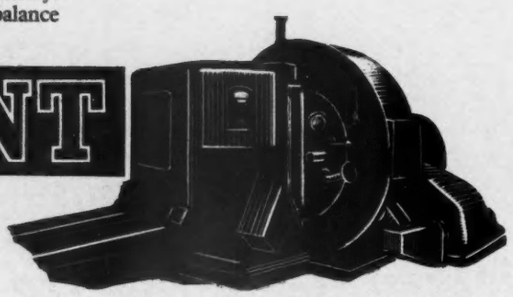

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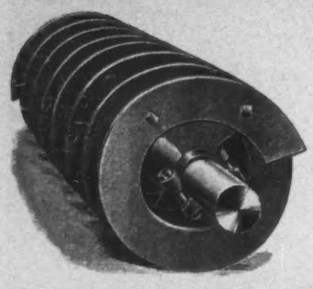

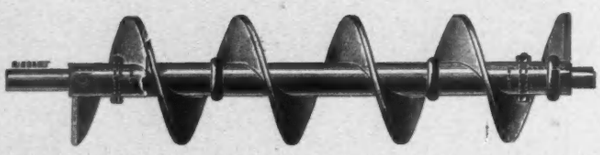

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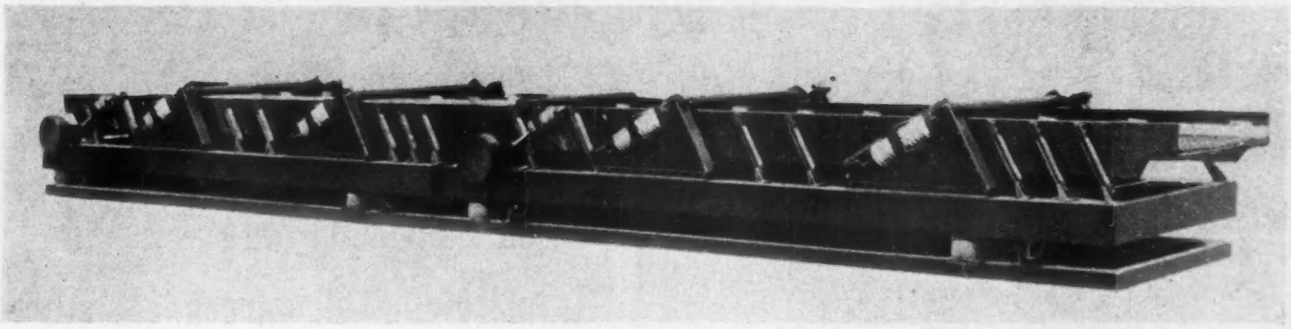

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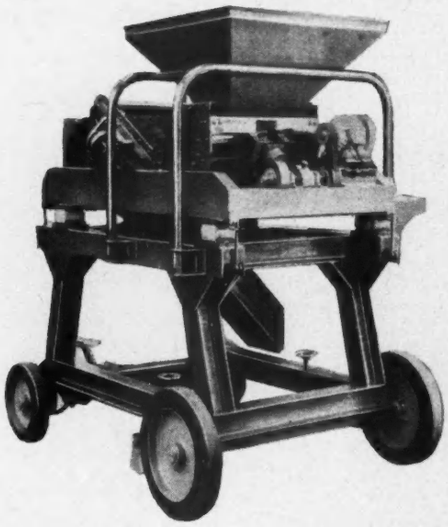

Small portable units are an economic consideration, especially in the smaller plant where intermittent screening is required, for instance, below bunker outlets or at conveyor discharge points.

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Edgar Allen & Co. Ltd. are now manufacturing and selling in this country the Pintsch-Bamag Resonance Screen—acknowledged to be among the most efficient screening devices available. Full information in Publication No. 143—use the request form below.

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Illustration shows part of two complete trains used to deliver.

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PAL14A

Up in the air...

BARIMAR tackles "a really awkward job" of Welding

Our engineer readers who hail from all over the world, as the Barimar letter-bag proves, will read of this "intricate" job of welding with lively professional interest. They will appreciate the skill and resourcefulness and, above all, the apparatus necessary, to weld a heavy fracture like this "up in the air".

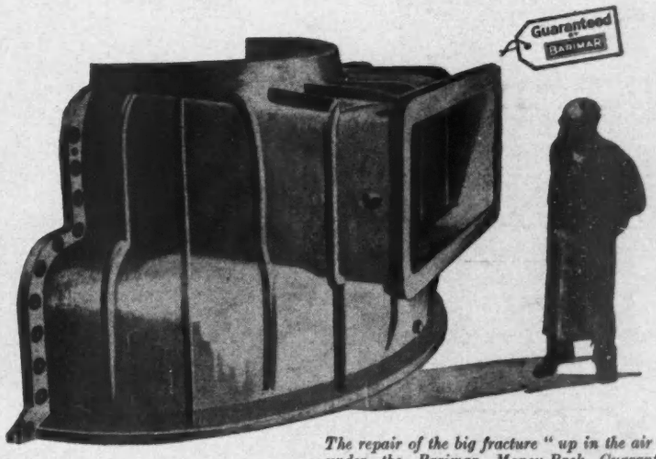
The damaged bottom half of a Blower Inlet Casing, weighing five tons, that came to Barimar for repair.

The photographs illustrate the bottom half of a Blower Inlet Casing weighing five tons. A large portion of the heavy flange surrounding the aperture was fractured and broken away. Not a simple honest-to-goodness fracture, but one made exceptionally difficult by reason of its position and the presence of the partitions or vanes in the large rectangular aperture, and the ribs outside the casting.

The owners recognized that the welding of a heavy and complicated fracture like this was a job that only experts could be expected to tackle—so they sent it to Barimar, stressing urgency, conscious at the same time of the alternative heavy cost of a replacement.

Within a few days the repair was completed, thoroughly tested and sent home for re-assembling, covered, of course, by the Barimar Money-Back Guarantee. Time was saved, considerable expense avoided, and the owners were assured that the reconditioned casing would "stand-up" to its work for a long time.

PLEASE ADVISE when sending damaged parts, making certain that they are despatched CARRIAGE PAID and all fittings are removed. When it is impossible to transport damaged machinery Barimar experts will operate ON THE SPOT.



The repair of the big fracture "up in the air", under the Barimar Money-Back Guarantee saved the owners of this Blower Inlet Casing great expense, and avoided loss of valuable time.

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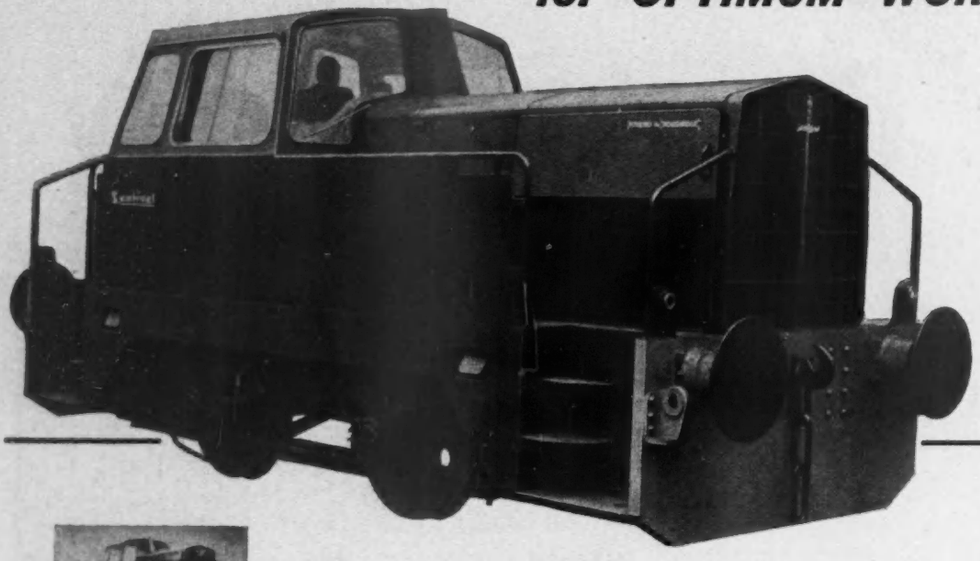

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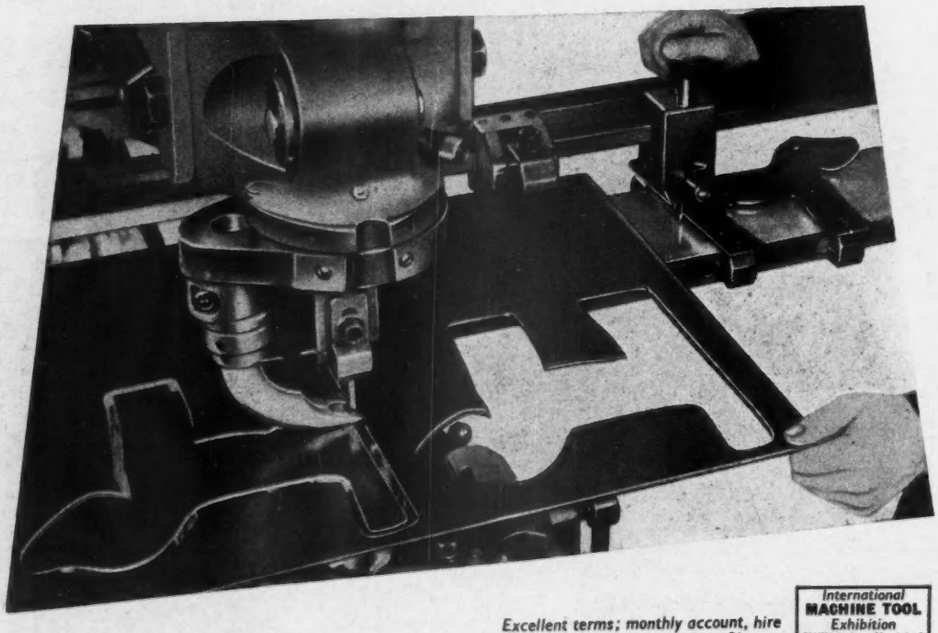

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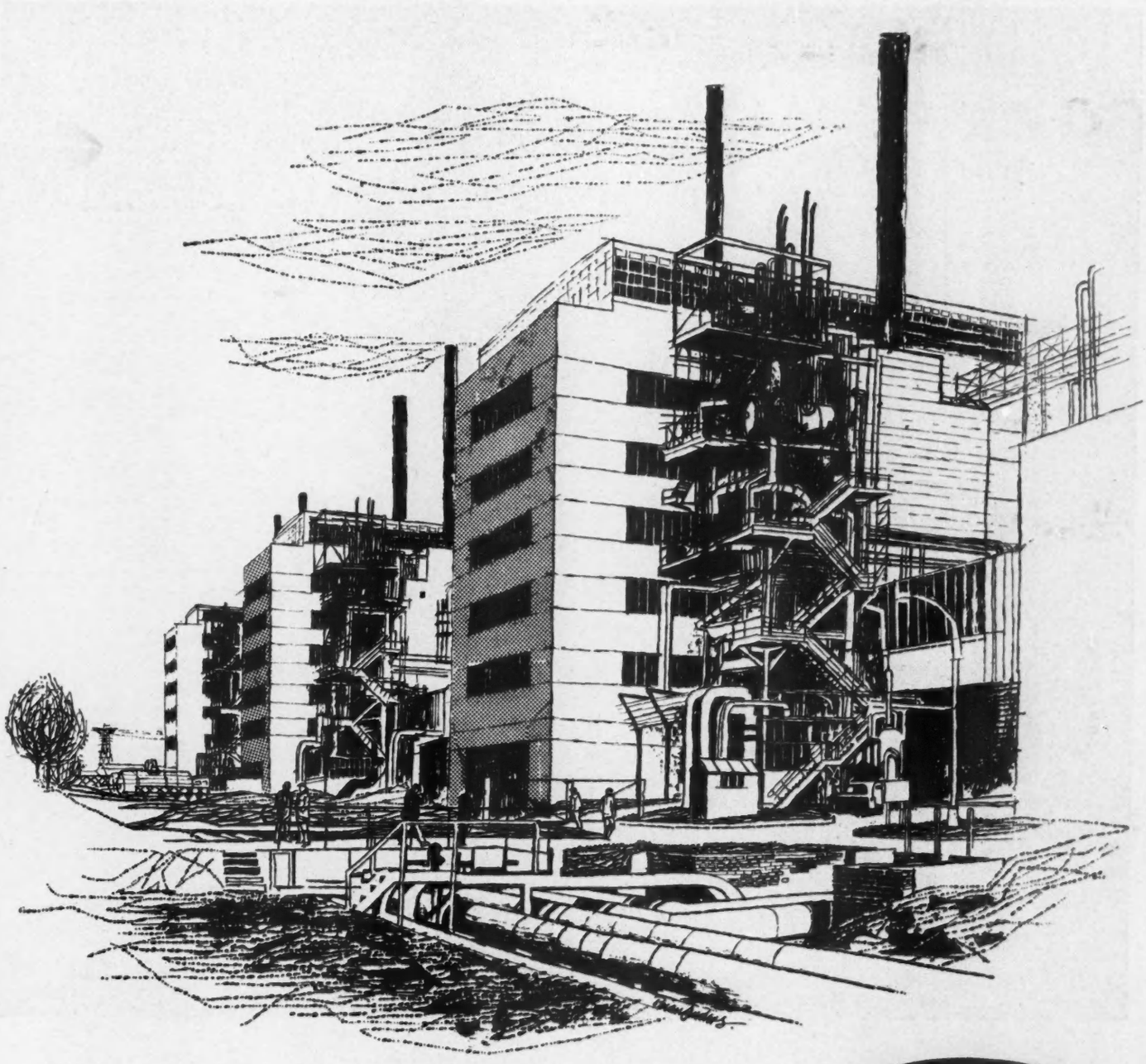

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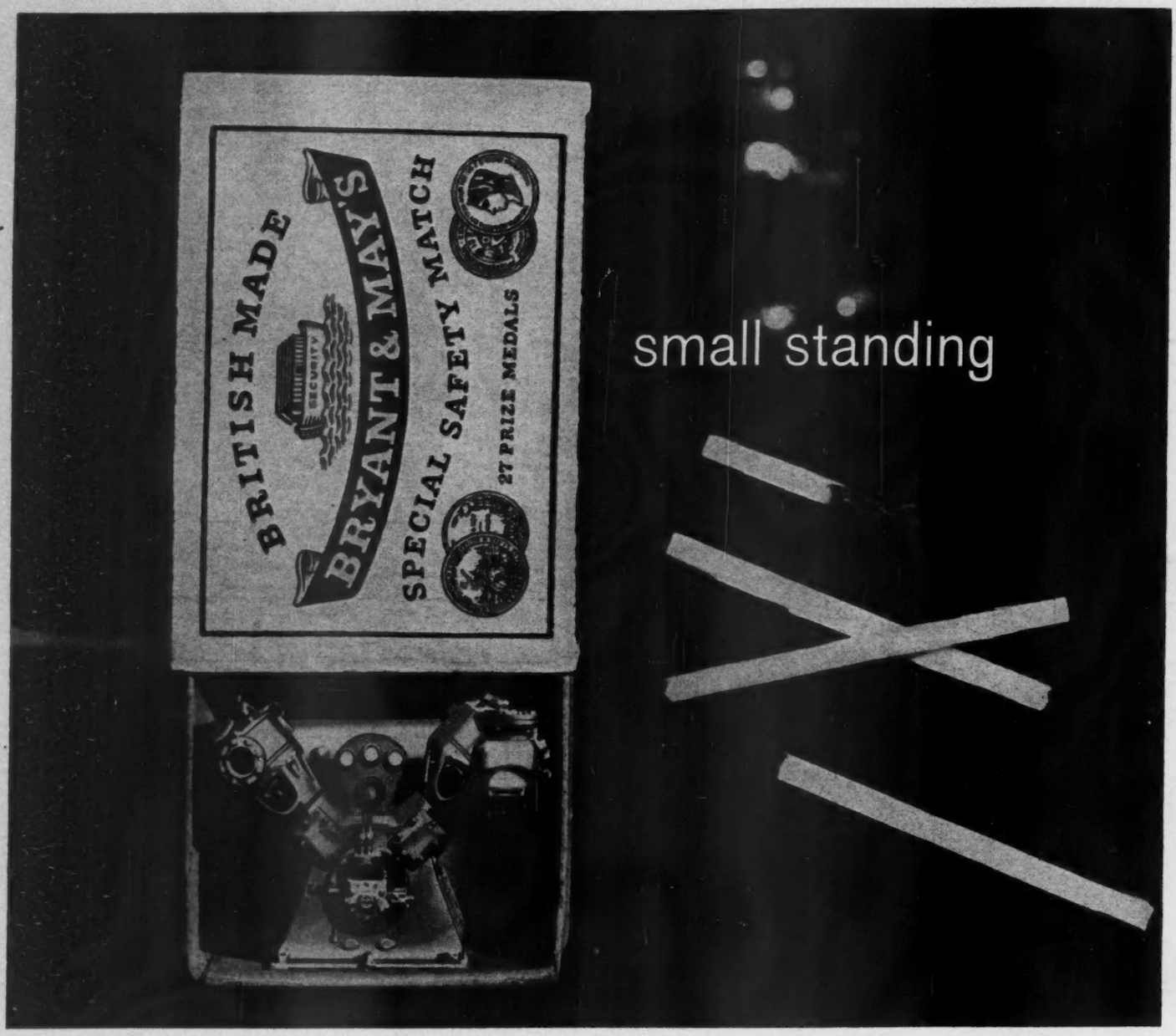

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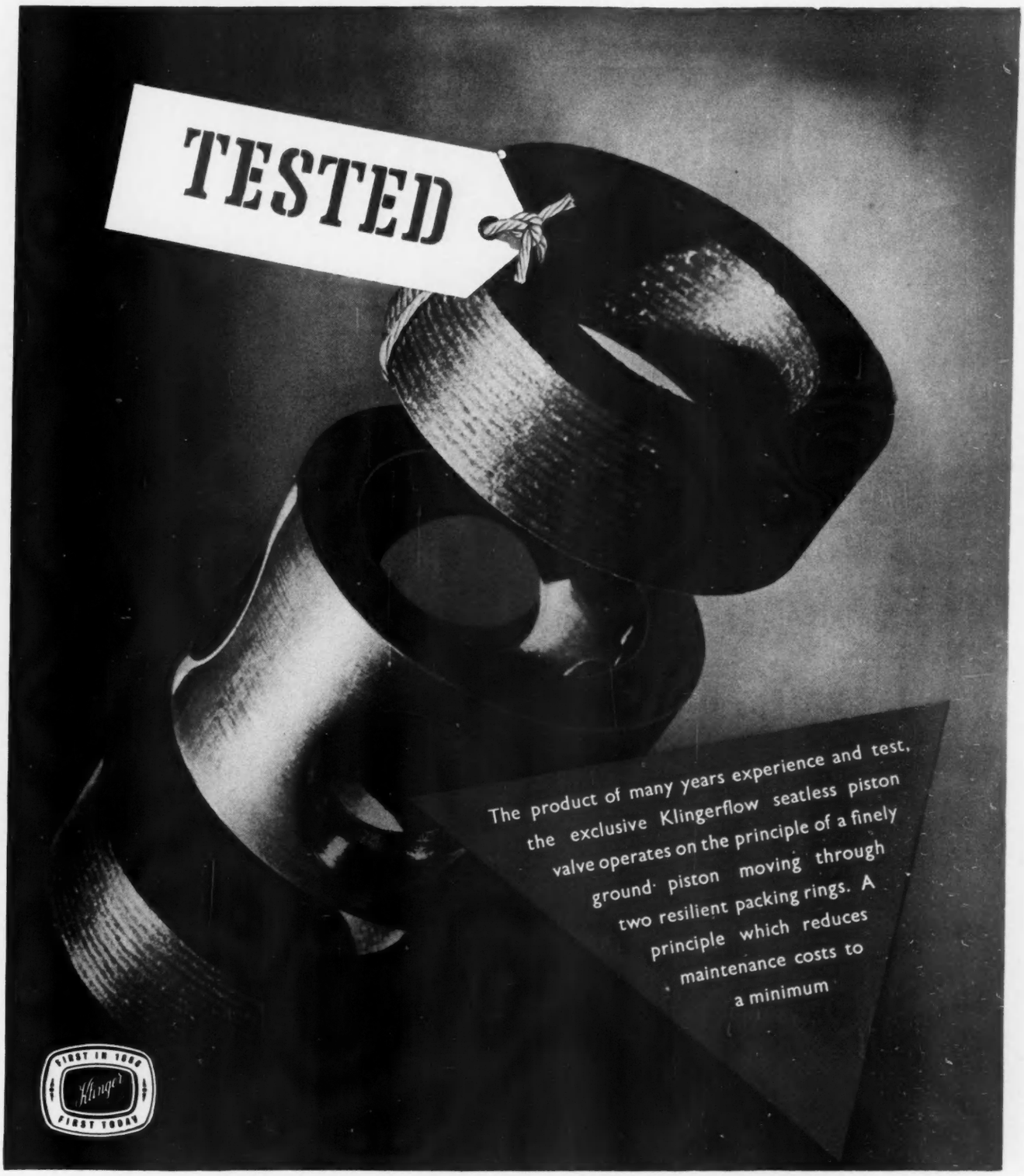
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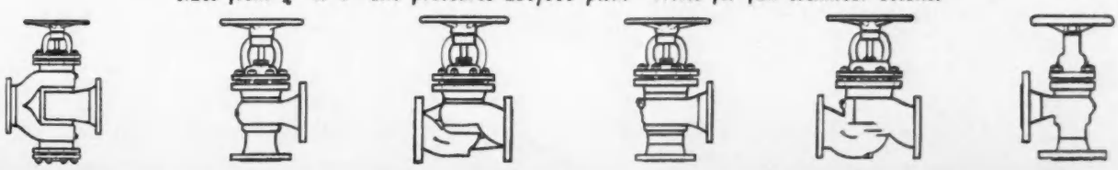

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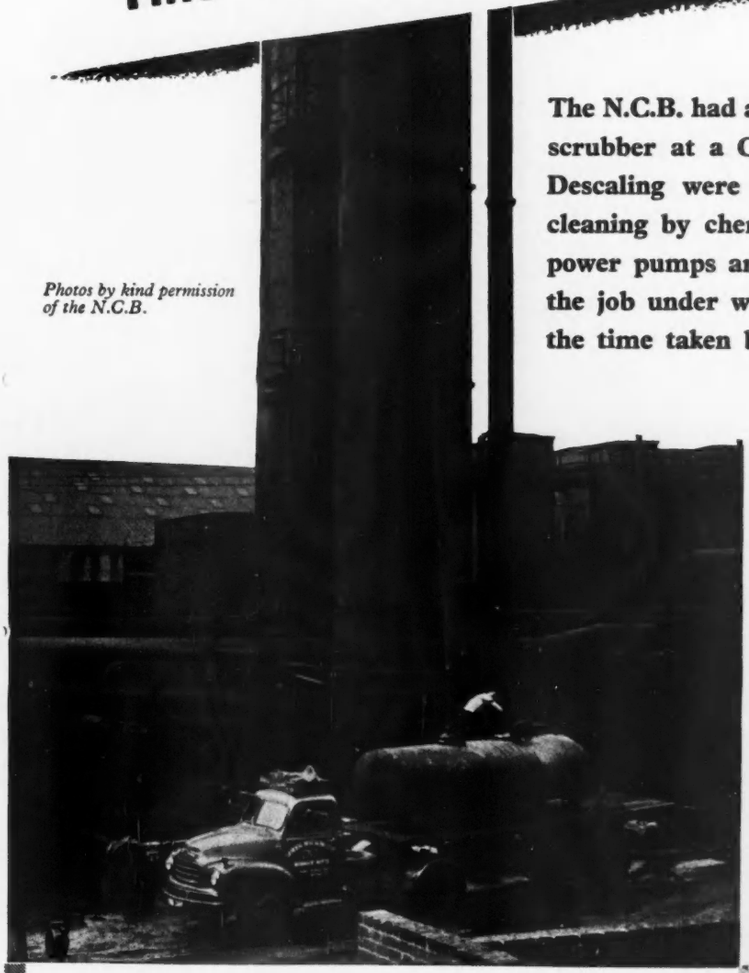

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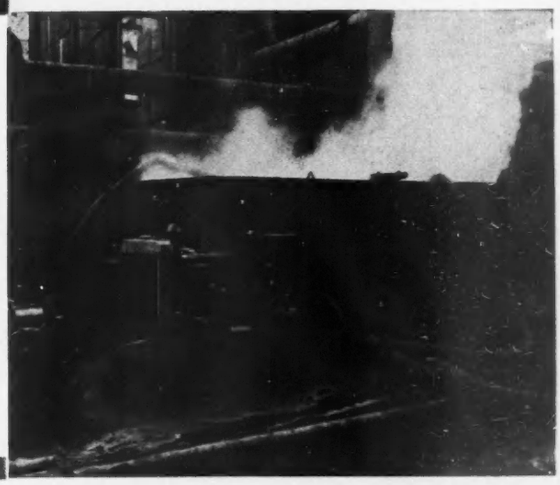

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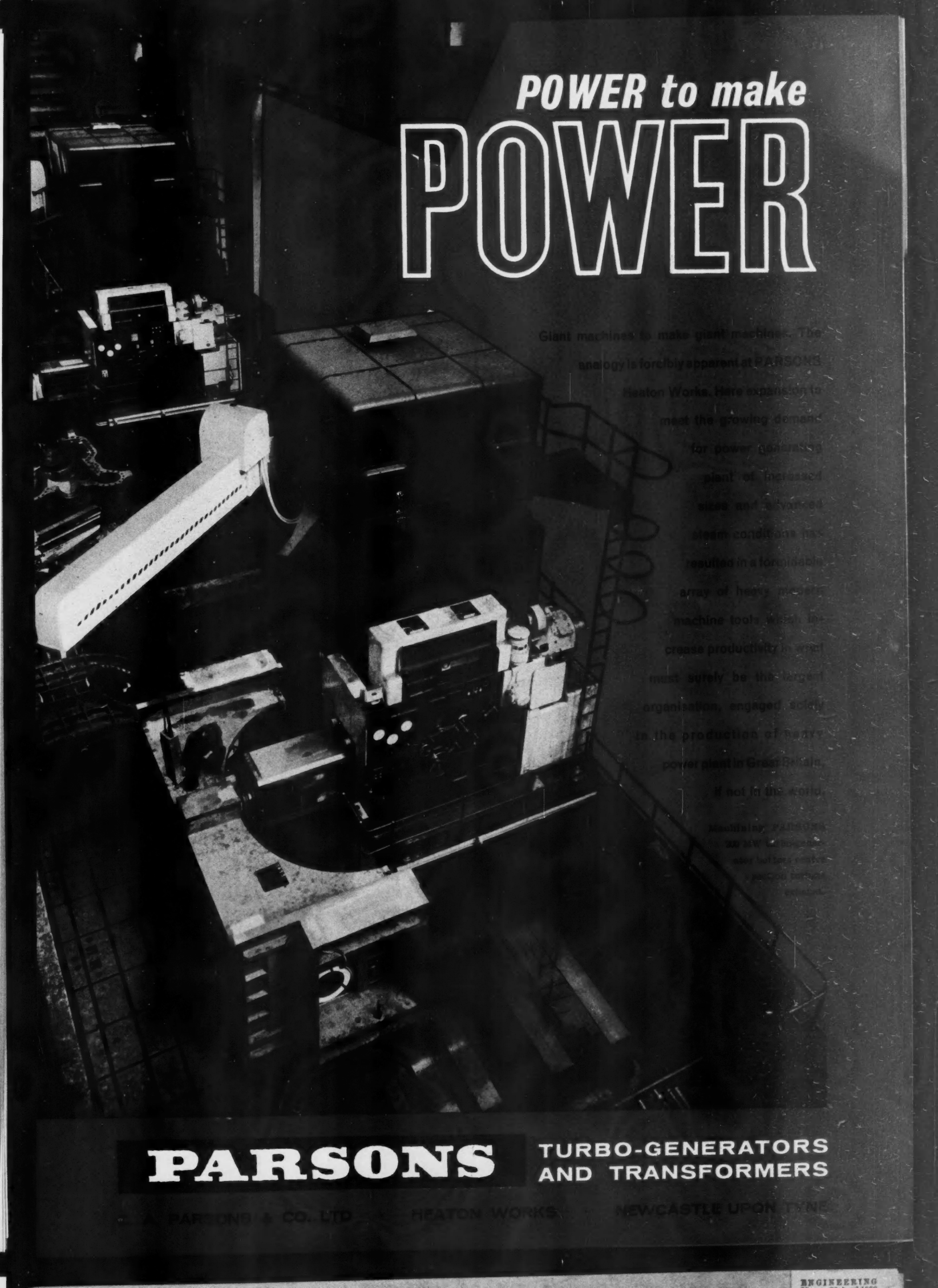
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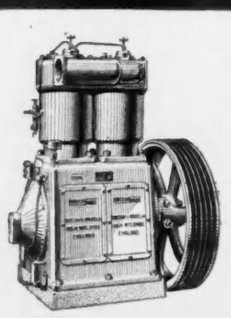

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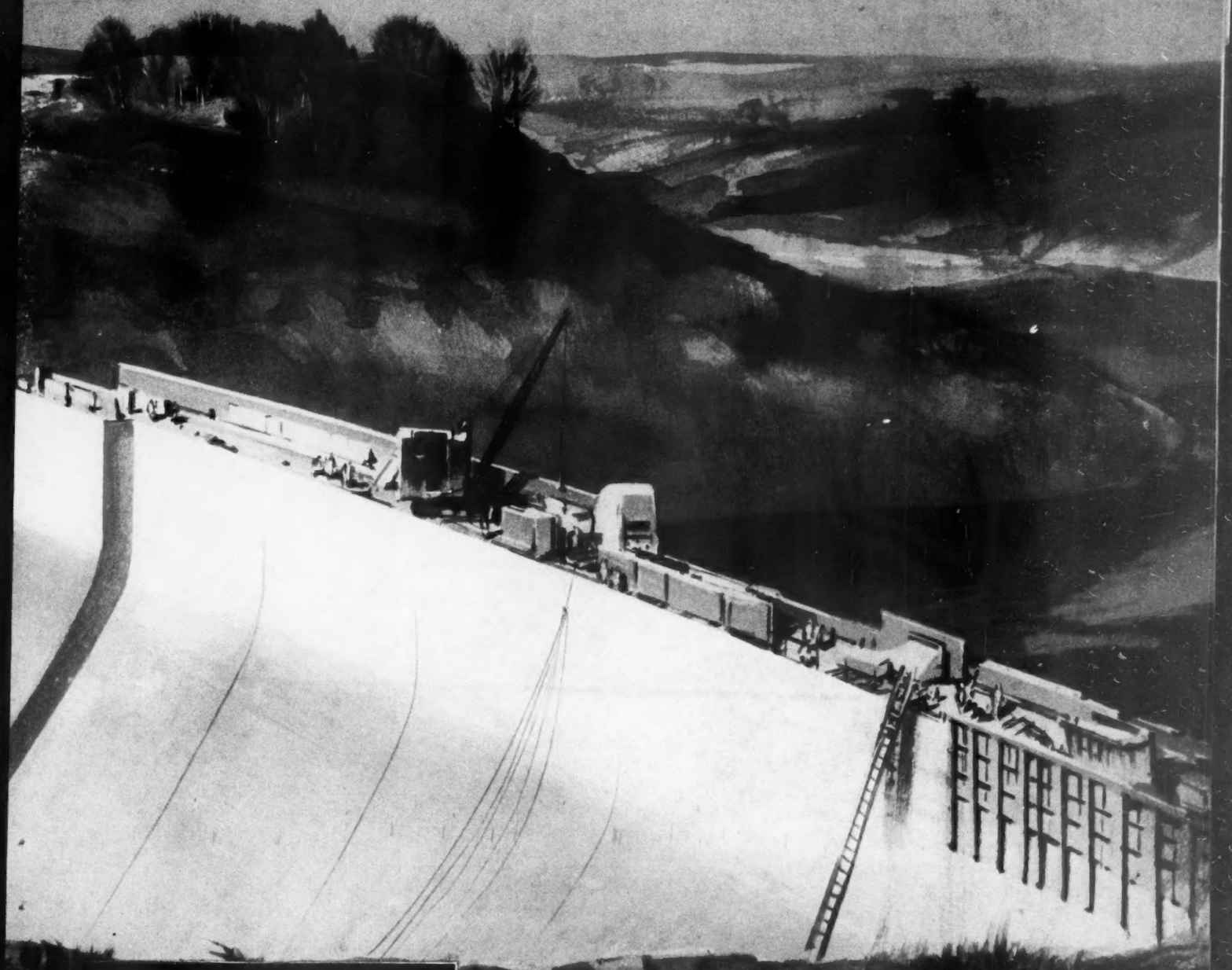

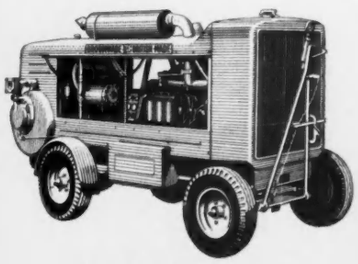

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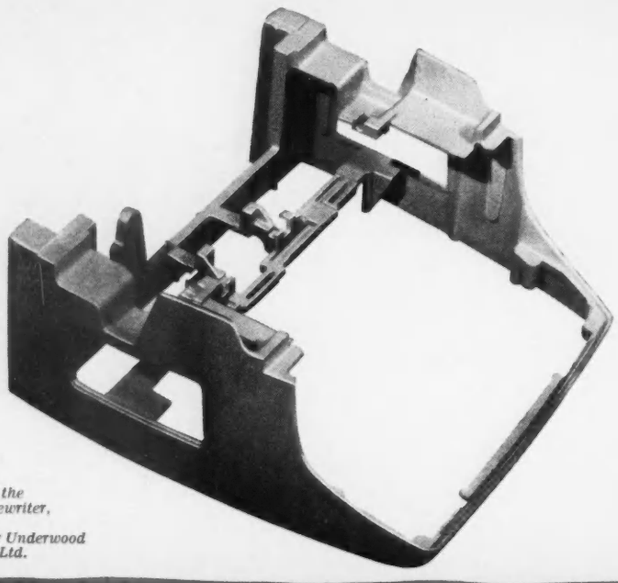

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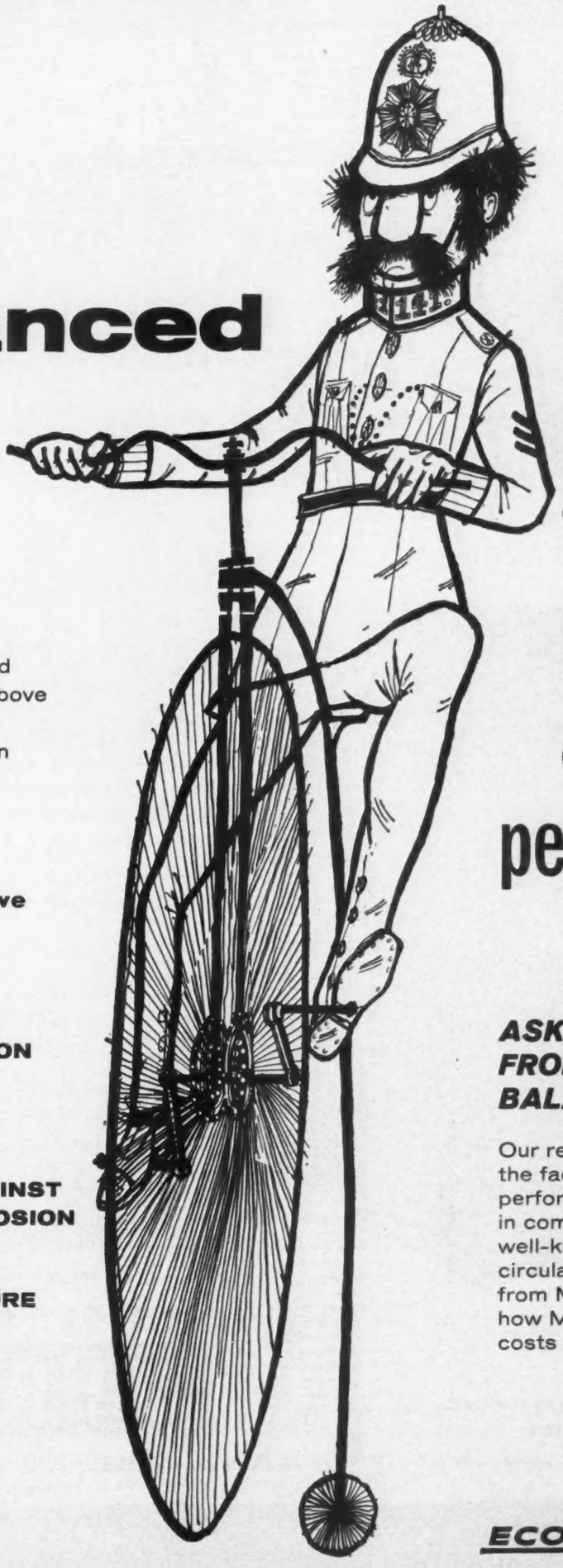

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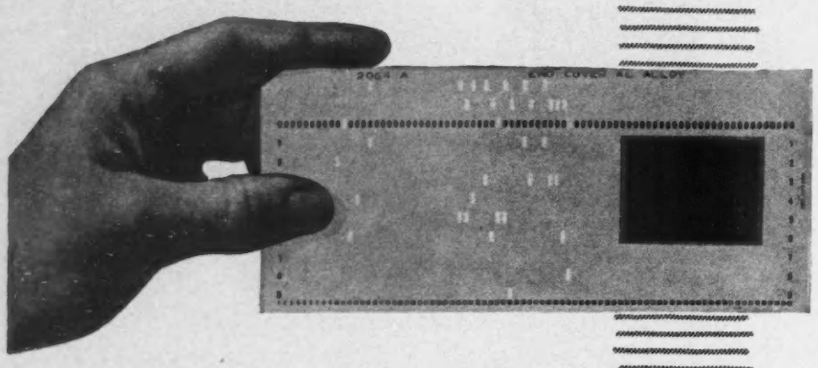

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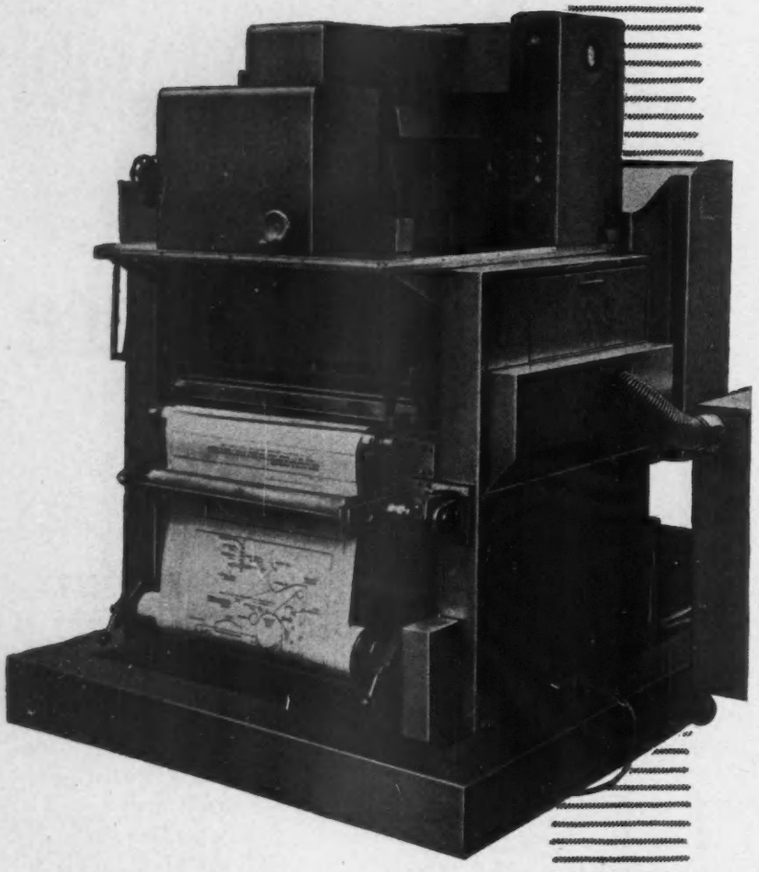

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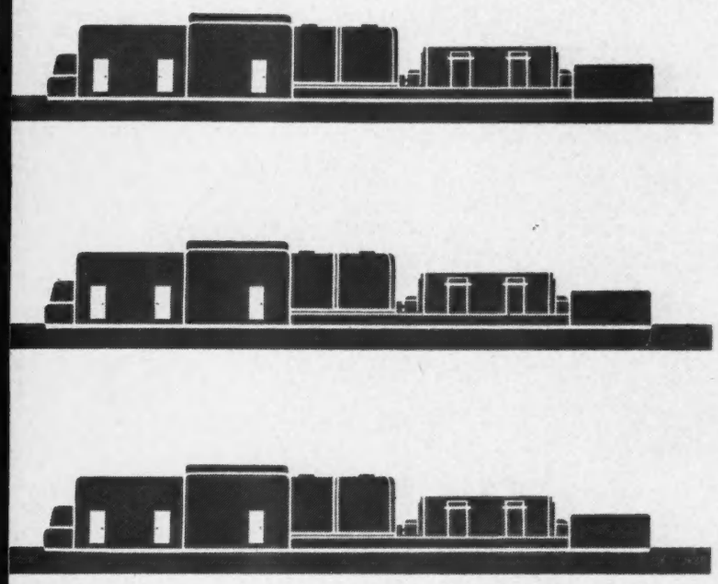

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Most economical rating	120 MW
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Generator voltage	13,800 volts
Power factor	0.8 lagging
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Steam pressure at inlet flange of reheat steam valve chests, at C.M.R.	375 p.s.i.a.
Steam temperature at inlet flange of reheat steam valve chests, at C.M.R.	1,000°F
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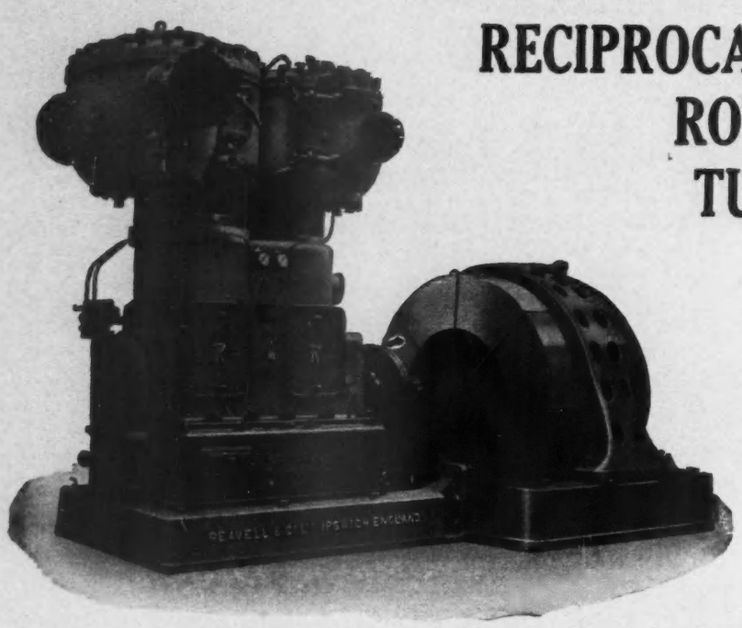

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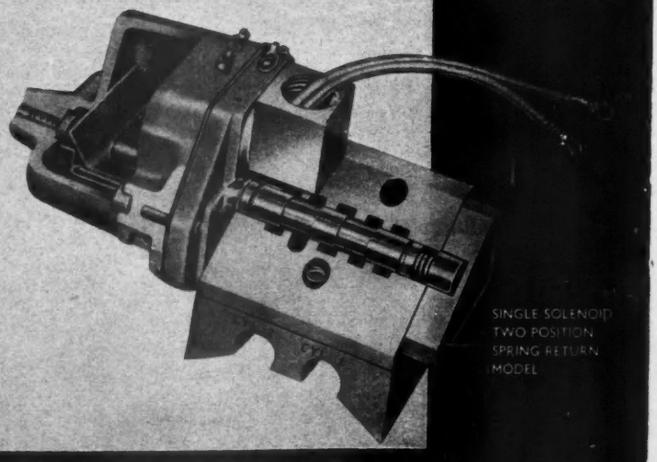

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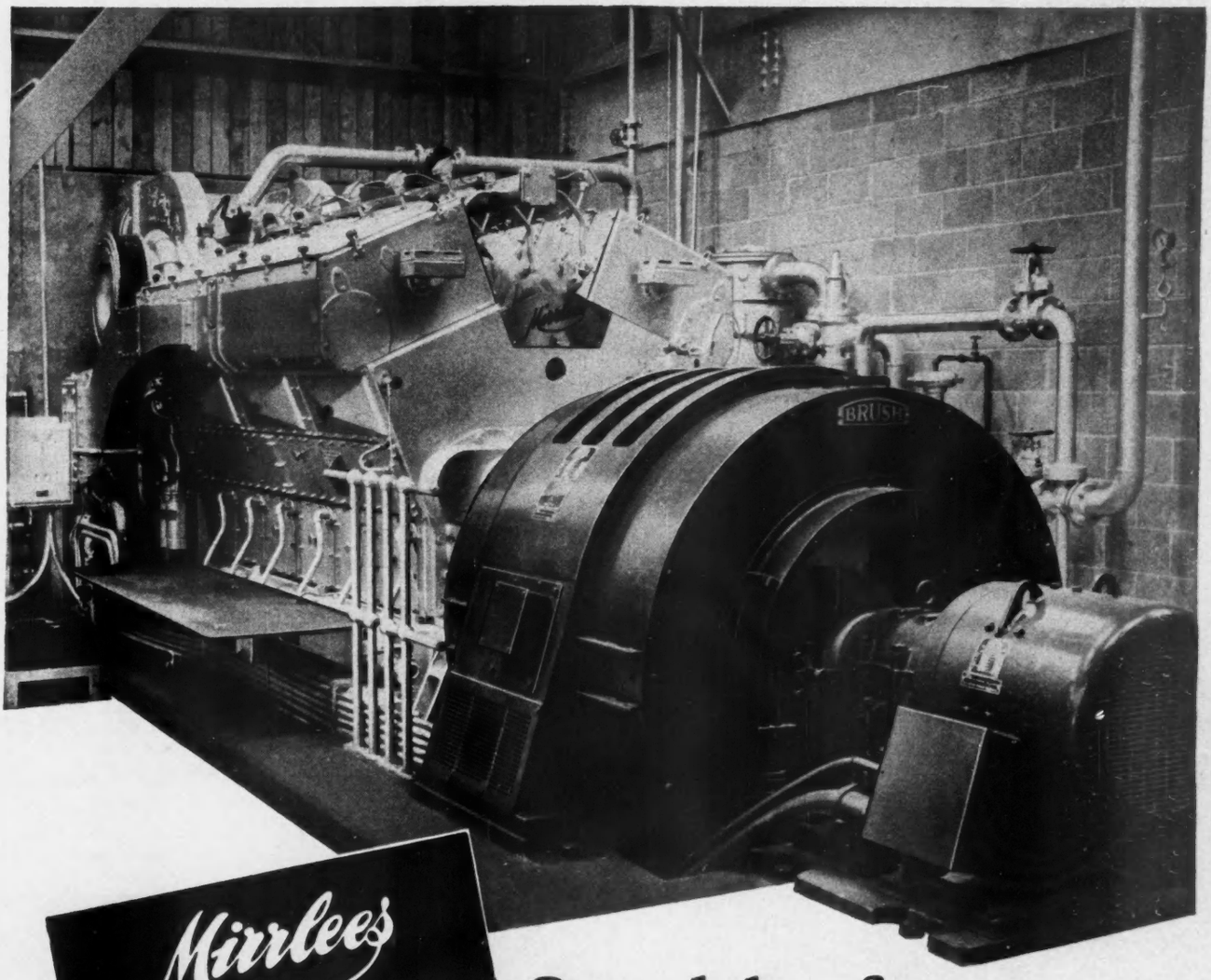

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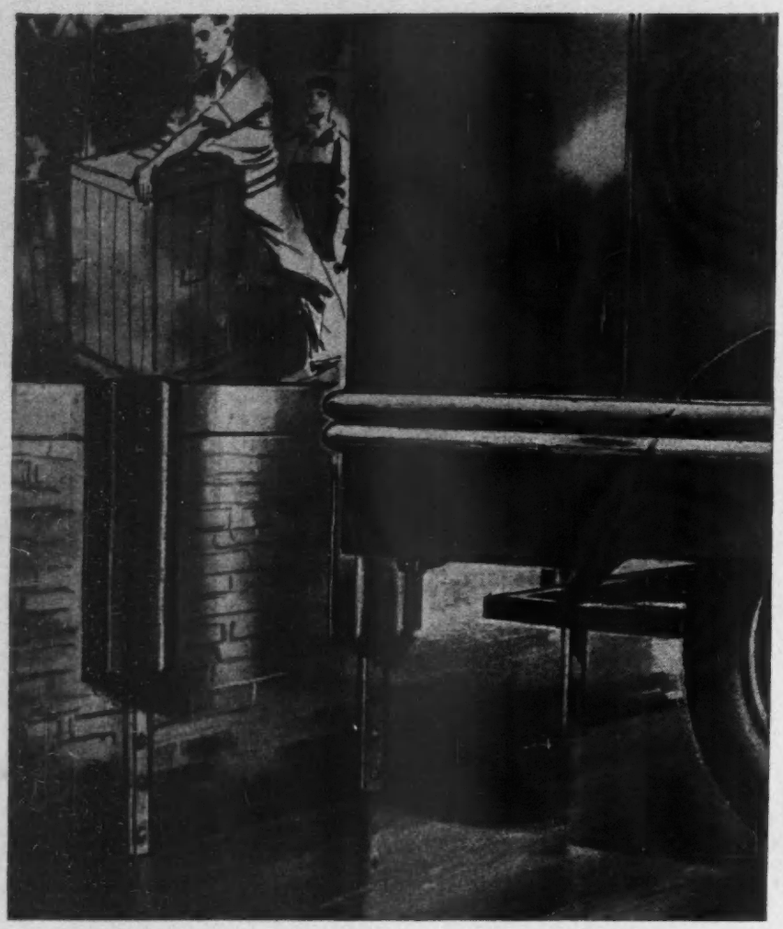

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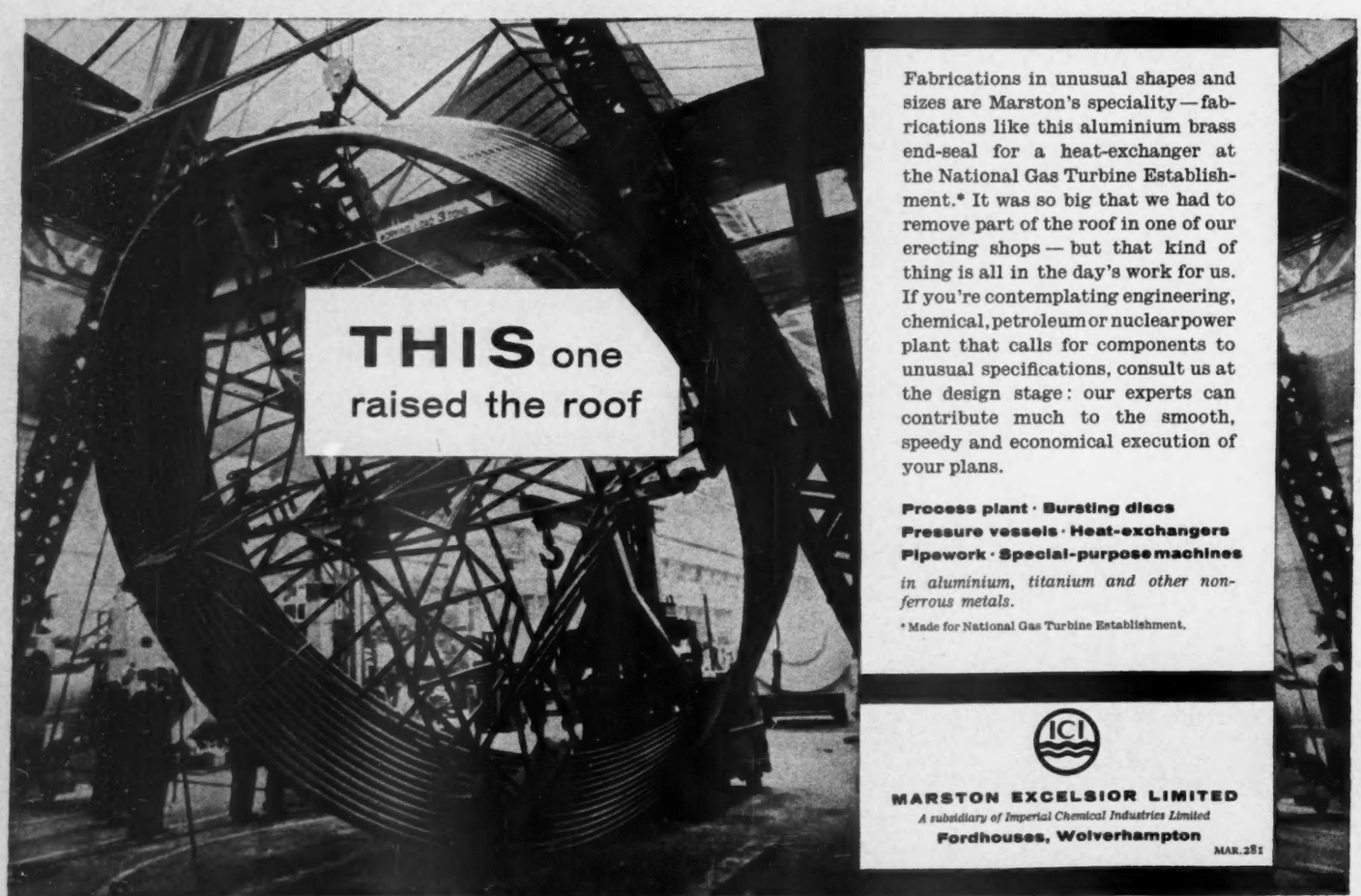

Fabrications in unusual shapes and sizes are Marston's speciality — fabrications like this aluminium brass end-seal for a heat-exchanger at the National Gas Turbine Establishment.* It was so big that we had to remove part of the roof in one of our erecting shops — but that kind of thing is all in the day's work for us. If you're contemplating engineering, chemical, petroleum or nuclear power plant that calls for components to unusual specifications, consult us at the design stage: our experts can contribute much to the smooth, speedy and economical execution of your plans.

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ENGINEERING Impact

of Turning Away from the Big Rockets

THE implications of the abandonment of the Blue Streak missile as a defence weapon go far beyond the loss of £100 million. There is the possible redundancy at the De Havilland Propeller company and the absence of any British deterrent apart from the V-bomber force.

The Blue Streak programme may or not have been obstinately pressed forward after it had become apparent that as a deterrent the missile was a waste of time. The development was first of all begun on most reasonable grounds, when the accuracy of Russian rocketry was not known, when the approaching period of abundant fissile material had not been detected.

But the thing has gone sour. The manufacturing capacity of the finest companies in the country, the energies of some of the best engineers and scientists, resources and money have all been lavished. Unless Lord Hailsham, the Science Minister, can achieve the difficult task in a time of rising Government spending of gaining acceptance for a space research use of Blue Streak the £100 million effort will have been largely wasted.

For the aircraft industry, this is the first important Government step since the amalgamations were put through. The chairman of Hawker Siddeley observed that he was not particularly keen to go further into the aircraft business but there were promises of Government support activities. Now the De Havilland interests are part of the Hawker Siddeley group and one of the first problems they bring with them is not of allocation of contracts but of redundant staff and workpeople.

Sooner rather than later the Government departments and the two big airframe groups have to decide on the British airliner to contend for sales on the airlines beyond the day of the present big jets typified by the Douglas DC 8. The fate of the Blue Streak sharply underlines the difficult position of the British aircraft industry, marshalled into two administratively complex groups, closely involved with Government policy and faced with development costs rising out of all proportion to our national income.

Defence or Investment?

Events have overtaken Blue Streak. And it is open to question whether the hundreds of millions that would be demanded by a programme in any way approaching the missile efforts of the scale going on in the United States or Russia could ever be afforded by this country without abandoning its position at the centre of the Commonwealth. Such military spending would reduce us to the condition of the Greek Spartans.

Hot war between East and West may or may not be unlikely. But the contest is joined in Asia, the Middle East and Africa; no doubt before long it will spread to South America. Every time an emergent country looks round for roads or harbour works, hydro-electricity or a steel works it faces a choice. Whether to have the work done by Russian engineers or by firms from America, or Britain or Europe.

The battle is joined along this front. The abandonment of Blue Streak could be the first step towards the authorities acknowledging what missile schemes really cost. And after that should come the most vigorous possible pursuit of constructive aid for the countries of the Commonwealth and beyond.

Rejection for UK Navigation System

Rejection by an international body of a complex navigational system is not exactly the best kind of stimulus for those working on its development.

This is what has happened to the Decca company's Navigator system which has been turned down by the International Civil Aviation Organisation. The ICAO decision, favouring the United States VOR/DME system, means that the Decca system will not be standard equipment on the international airlines.

It does not mean that the Navigator system cannot be considered for use on its merits. And it is improving these and taking out the snags that is the challenge intensified by the ICAO.

Already the Decca engineers have produced a significant step forward in computer design. A very small computer is the result. It can be carried in the cockpit and translates the navigational information of the system on to a conventional map in exactly the manner of the American VOR/DME. And the Decca results are said to be more accurate.

The future applications of the system appear to include the broadcasting to the ground of the computer's calculations. This would be of immense benefit in air traffic control around increasingly busy airports and in ground controlled landings.

The technical benefits of the Decca Navigator appear to have been raised by its development group to an engineering level where the adverse effect of the ICAO ruling may be overcome.

Coal and Steel Prospects in Europe

A slowing down of the rate of growth in the European building and foodstuffs industries may cause industrial production to rise less swiftly in the second quarter of the year.

This is the main point of the review of the coal and steel situation in the countries of the European Coal and Steel Community given by M. Roger Meynaud, a member of the High Authority. In the first quarter of the year it is believed that the 7·3 per cent rise in production which took place last year over 1958 had continued.

A combination of active competition from Japan and the fast recovery of the United States steel industry from its four-month strike reduced export orders. But the European steel industry is as hard put to it as the British to keep up with all the demands made upon it and its capacity will be fully in use throughout the second quarter.

The slow lift in coal consumption continues but not fast enough to remedy a situation the High Authority finds disturbing. The second quarter's total consumption is expected to rise above 1959's same period by 5 per cent. This is made up of 9 per cent more for the coking plants, 10 per cent for power stations and 4 per cent for domestic consumers. The other industrial users are expected to maintain their demand but coal consumption in other sectors of the economy is still falling.

of Cancelling an Independent Deterrent

If, as the Pentagon suggests, the V-bombers are not big enough to carry the Skybolt missile, cancellation of the Blue Streak rocket may mean the end of an independent deterrent. The problem is then to salvage some of the investment in the deterrent, which is not just a rocket with a warhead, but a defence system involving the whole industry of the United Kingdom.

In addition to money sunk directly into missile development, large sums invested in nuclear weapons will be written off as a result of cancellation. The total is staggering: it includes the cost of nuclear tests, most of the Aldermaston research complex, most of the Capenhurst enrichment facilities, a large part of the plutonium separation and fabrication plants, the Windscale piles, and most of the cost of eight reactors at Calder Hall and Chapelcross. Only a continued vigorous nuclear power programme offers any hope of salvaging this investment.

But if the United Kingdom has no more use for nuclear weapons, very large amounts of plutonium will become available—both from stock by dismantling the bombs, and from the civilian and para-military nuclear power plants which continuously produce plutonium. This material has been totally written off as an explosive: it can now be used to provide really cheap enriched nuclear fuel.

The cost of fuel still accounts for about one third of the cost of electricity from enriched-fuel nuclear plants—there is plenty of room for improvement. It is the high fuel cost that puts nuclear power plants at a disadvantage in competing for markets. The Dounreay station will use pure plutonium fuel. But to make immediate use of the available stocks of plutonium, experiments with plutonium-enriched fuel and reactors capable of using it are required.

A vigorous nuclear power programme is absolutely necessary to derive benefit from the large and unused military investment in nuclear weapons. The basis for such a programme lies in the cheap fuel available through enrichment with plutonium, which may be obtained from the redundant military stores and production plants.

Setting the Post Office Free

Now that commercial freedom has been granted to the Post Office it may be that the next few years will see a pace of technical development in its services that will match the speed achieved in aviation and in electronics.

There are a number of challenges to the engineer and he will have the double stimulus of the Post Office being able to develop its most profitable lines and rigorously to re-examine those that lose money, such as telegrams and telephone kiosks.

For the general subscriber the only thing that the telephone instrument has been allowed to do in the way of progress is to come down off the wall bracket and squat on his desk. Now there will be fresh impetus in the efforts being made to produce a loudspeaker telephone that needs no hands. A press button telephone, with which most of the time spent getting a number would not be spent watching the dial spin back into place, is another logical development which the new regime may perhaps develop for its subscribers. Such improvements should follow easily after those made in trunk dialling.

The field trials at Norwich on the substitution of code numbers for the present cumbersome form of addressing letters should give another branch of the Post Office the information and practice it needs for a complete evaluation of this next reform.

Basic to the whole telephone problem is the high cost of capital tied up in the installation of a single telephone. It is officially put at more than £100. The engineer who solves the transmission problems responsible for this will make the telephone as common in the home as piped water. It may be that the change in the administrative conduct of the Post Office will alter conditions to make this engineering break-through possible.

and Developments in Research Spending

The average cost to his company of an engineer or scientist engaged on research or development in manufacturing industry (other than aircraft) was almost £8,000 in 1958. Three years before the average cost had been £5,600 a year.

With the cost of a qualified research worker in the aircraft industry in 1958 was £31,000, the average taking in aircraft rose to £11,000.

The Department of Scientific and Industrial Research survey arriving at these important costs shows that the United Kingdom's manufacturing industry spent about £300 million on research and development in 1958, against £190 million in 1955, a rise from 3·1 per cent of industry's contribution to national production to 4·2 per cent.

As would be expected the main headings for industry's research and development were aircraft, £100 million; electrical engineering, £64 million; and chemicals, £43 million. The DSIR inquiry went to 502 firms engaged in scientific or engineering work. "Usable returns" were 292 which formed the basis of the results and they have been published in "Industrial Research and Development Expenditure, 1958."

That the cost of paying and providing for a research worker should be so substantial, though not new itself, may explain why small firms must leave so much of the work to the industrial giants and to joint bodies. It does not explain why the motor industry should not be among the first three or why the aviation firms should spend so much more on their research teams than some others, including shipbuilding and machine tools.

Appropriate in this context is Lord Hailsham's recent remark that, while in Britain £25 is spent per head on fuel each year, only a penny a head is spent on ventilating and heating research.

Curtain Walls and Cladding

Architectural "cladding" over a load bearing skeleton can exploit a wide range of materials. Chosen correctly, the surfaces can enhance both general and industrial buildings.

CURTAIN walling can result in delightful architecture, but used badly it can spell monotony and formlessness. The good aspects emerge when new colours and textures are exploited in a building which is not devoid of modelling.

A curtain wall, or even cladding of any kind, is like an overcoat—the skeleton exists underneath. Being non-structural, it can exploit weak materials like plastics and thin vitreous enamelled sheet metal. This, of course, means that buildings can go higher for the same weight, and that erection, especially with factory-made units, is made easier. Given the most beautiful materials in the world, though, it would still be possible to design a hideous monument; what follows is therefore a description of what the architect has at his fingertips. How he uses these is another matter.

The majority of curtain wall systems available as standard productions in this country consist of secondary light framing of metal or timber fixed to the main building structure. Such a framework, usually with mullions which span from floor to floor and horizontal transome members, built up a frame into which window or opaque units are fixed to form the complete screen. Another alternative is the storey-height panel, often factory fabricated as with the Laingwall system, which, being a self-contained unit, completely fills the space between floor slabs.

Jointing is one of the serious troubles in curtain walling. Panels expand and contract under varying heat, and the joints must accommodate this as well as continuously supporting the panel and remaining weathertight. Dry glazing techniques are now being used which employ neoprene and other plastic or rubber gaskets. Some of these are of the zip-in type such as are used for motorcar windscreen glazing. Others are simple U sections maintained under pressure with the bead. A whole group of new cold setting rubber compounds have now come on to the market, the best known of them being the thiokols. The two components are mixed just prior to use and a caulking gun used for application. The finished material has a true rubber-like nature and adheres both to glass and metal.

Metals

Aluminium.—Cladding of this metal weathers to a pleasing grey colour. The finish can be maintained in original condition for indefinite periods even outdoors by washing with water and soap or detergent, perhaps two or three times annually.

Although widely used as extruded sections for framework, aluminium has not found wide use as infilling in curtain walls. In industrial cladding, it has, however, made a great impact. Rigidall Seamwall, made by British Aluminium Company, is one of the bold new profiles on the market. This incorporates a specially developed method of concealed fixing. Long sheets are available, up to 40 ft, so that from eaves to ground level can normally be covered with one course.

Stainless steel.—No special precautions are required beyond simple washing with leather and water when the windows themselves are cleaned. In heavy industrial or marine atmospheres, the molybdenum-stainless steel 316 is preferable, but in rural areas normal 18Cr-8Ni-stainless steel is satisfactory.

Stainless steel is usually embossed, patterned, or finished with a matt surface. Such was used on a two storey chemical laboratory at the Stocksbridge works of Samuel Fox and Company. Wall panels consist of 26 gauge stainless steel sheets, diamond patterned and electropolished to a matt finish which prevents glare and reflectivity.

In America, Allegheny Ludlum Steel Corporation is now offering coloured stainless steel, first of all in shades of brown and black, soon to come in blue, green, red and grey. This new process requires no pretreatment, nor any primer undercoat. There is good uniformity of colour, good surface adherence, and abrasion resistance. Needless to say, the largest market foreseen by the makers is for cladding.

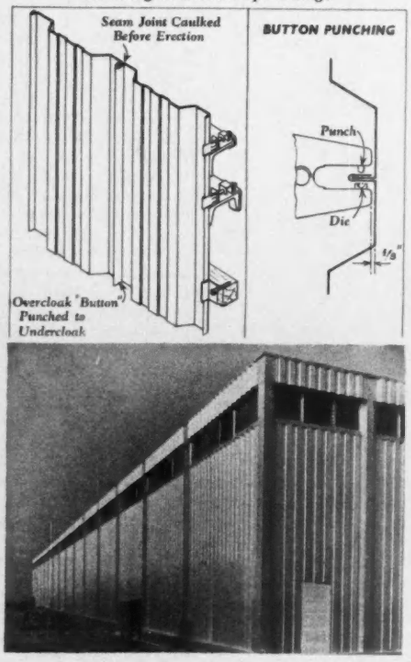
Coated Metals

The range of precoated metals is enormous, and one must include galvanised and aluminised sheet as well as vitreous enamelled steel and aluminium, and the plastics-coated products. Galvanised and aluminised sheet are not going to be mentioned in detail as they are well known for industrial cladding.

Vitreous Enamel.—This comes in any colour in the BS266 range and a variety of textures are also obtainable from full gloss, semi-matt, full-matt, or mottled to roughened finish. A new development is vitreous enamelled aluminium, finding much favour for patterned and textured sheet on balcony fronts, facia panels and soffits. Some of the chief advantages of aluminium base are its lightness and the ability to be cut, sawn or drilled after enamelling with no spalling. Vitreous enamel can be expected to last 100 years.

Vitreous enamelled sheet has been used in a variety of different types of infill panels. First flat panels of steel or aluminium bonded to a core such as asbestos board: the steel is normally 16 gauge and the edges of the composite panel are bound with pvc tape. Flat bonded vitreous enamelled infill was used on the Daily Mirror building and has excellent fire resistance. In fact, the panels which were installed on the Mirror building were undamaged after the recent fire. A ridged panel can be constructed with flanged edges and used in combination with asbestos or another solid core material, or without infill, for exterior cladding. This has been used with vitreous enamel extensively in South Africa with considerable success. There are a variety of panels bonded to an insulated board or filled with honeycomb paper and vermiculite; the back of the panel being sealed with a thin metal sheet or aluminium foil. Developments are proceeding with various other types of insulation material such as foam glass and fibre glass and any amount of variations with these can be produced.

Aluminium cladding with box profile is sealed by caulking and button punching.



Cotts House: precast mosaic faced slabs in patterned and plain colouring.

Plastic-Coated Sheet.—Although not being used in vast tonnages for external cladding, this has still been used for infilling in curtain walls, mainly on the Continent. Since the pvc is supported by steel, there is no need to worry about brittleness through ageing, but the colours must be stable. The makers of Stelvetite—John Summers and Sons—point out that the pigments they use reach grade 7 on the British Standards grading, which compares with the average figure of 5 for most paint pigments.

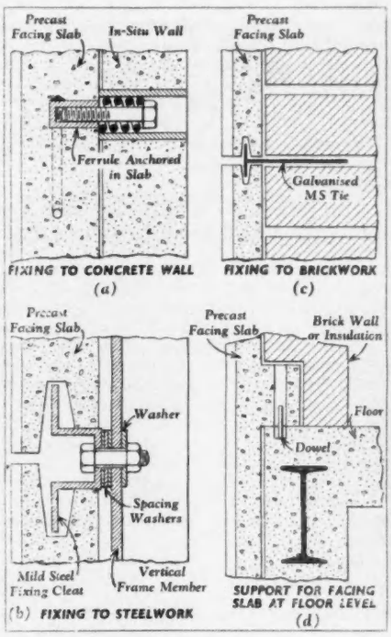
Enamelled sheet is making an appearance in this country, although still confined to widths of 18 in. Several aluminium companies are known to be interested in making the material and one of the largest outlets could be the building trade. It seems to be a matter of the life expectancy for there is no paint made which will stand up to outdoor weathering for more than 10 years.

One interesting precoated material is that made by Robertson Thain known as protected metal. The latest version is coloured. This is being produced in an attractive box profile and has a coating of zinc, asbestos, bitumen and modified alkyd finish which really defies corrosion. Its defiance of fire, however, is not quite so promising, although when coupled up with an asbestos lining it takes time to get going.

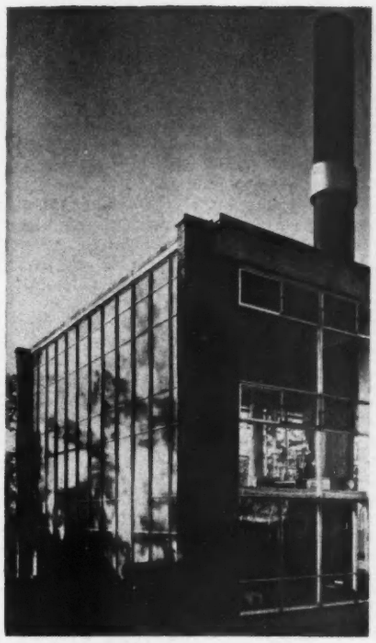
Plastics and Wood

Bakelite believe it is not too far distant when all-plastics wall panels will be produced. Already extensive use has been made of polyester glass sheet material for roofing and walling. Rigid pvc is coming with high weather stability. One of the bugbears with plastics is fire resistance and weathering. Pvc is non-inflammable but does not weather well at the moment. Perspex has been used for window lights, but is inflammable. Most polyesters have been considered inflammable till now, but there are several non-inflammable grades available.

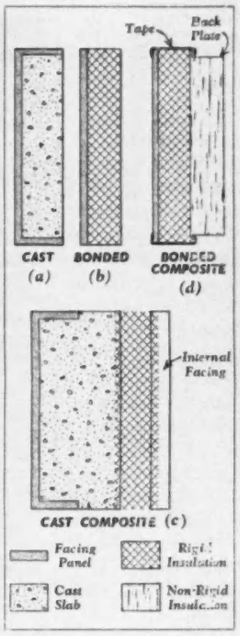
Plastics foam such as foamed phenolic can be



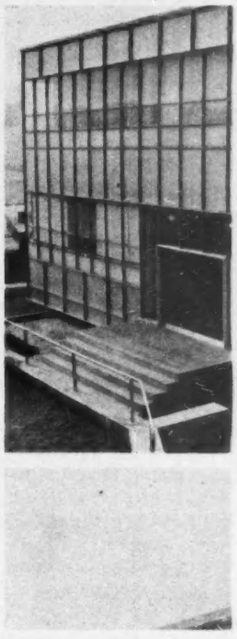
Methods of supporting precast facing slabs of mosaic or exposed aggregate concrete.



Glass curtain wall on boiler house. "The men like others to see it."



Four of the composite infill panels.



Stainless steel finished matt with diamond pattern.

used for insulation, and Bakelite have made several bonded panels faced with pvc-coated steel or filled polyester.

One of the panels illustrated is produced by Martin Goacher and Company. It is available in a variety of colours and patterned effects with virtually any degree of transparency up to 60 per cent. Three-quarter inch thick panels consist of two polyester glass skins incorporating a core of decorative motifs, the plane of the motifs being at 90° to skins of the panel. Edge of each is sealed with a strip of polyester glass, thus completely enclosing the air space.

Wood.—Wide variation of character are possible with wood, and richness of natural colour and texture harmonise well with brick walls. Fire regulations are important, however. In schools, for instance, horizontal or vertical fire-breaks are required between floors under the regulations of the Ministry of Education. Straightness of grain and soundness of timber are essential whatever the species selected. It is interesting that for one cladding project, work on matt-finished vitreous enamel panels was abandoned on account of cost. The material was replaced by boarding of Brunei teak.

(Top) Sandwich panels with phenolic foam. (Bottom) Double skin panels in polyester glass.

Ceramics and Glass

Mosaic panels are popular nowadays. The construction is similar to that of other types of cladding panels, whether they are in reconstructed stonework or exposed aggregate. The mosaic facing to the panels provides a durable finish and one which is self-cleansing and gives a lasting brightness of colour which is not readily obtainable in other finishes. Many of the mosaics used in this country are imported from Italy or Sweden and include glazed and unglazed.

Glass.—It is possible to incorporate lettering, patterns, symbols and designs of all kinds in a coloured cladding glass. This opens up the way to a genuinely architectural treatment of city advertising. Lighting for such cladding can be incorporated in the panel thickness. "The entire facade of the building," say Pilkingtons, "can become a rich feature of a city street which is at the same time both architecturally expressive and commercially striking."

For the tower block of the new Castrol House, infill panels are of Calorex glass. The tower is illuminated by cold cathode tubes accommodated behind the blue-green glass which gives the striking appearance of several trays of light.

Industrially, the Ilford plant at Mobberley has an unusual boiler house with glass curtain walling. "Not only is this aesthetically pleasing," say the company, "it is also extremely functional. It encourages the attendants even more to keep the equipment in spotless condition; they take a pride in the job and like others to see it."

Cement Products

Plain concrete facings look very dull, but with the aggregate exposed they can be exciting. In addition, an extremely wide range of effects is rendered possible by making use of patterned or profiled slabs, even without colouring.

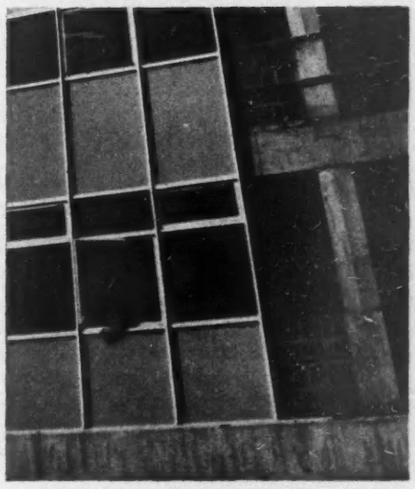
Allowance must still be made for expansion of the slab. Because of the greater weight even as a "veneer" for infilling, the manner of supporting it must be more substantial than an aluminium extrusion as used for glass. Hence slabs are supported on the main floors or can be affixed to a concrete or brick well, itself built on the floors. In this way the veneer can cover up the otherwise exposed floor slab.

Asbestos-Cement.—"In some minds," say Universal Asbestos Manufacturing Company, "the low cost of asbestos-cement has excluded it from consideration as an architectural medium. There is increasing recognition, however, of the fact that the material has a potential for high design standards, as exemplified by Continental practice and a small but growing number of buildings in the United Kingdom." Two factors are important in this respect: selection of the most appropriate sheeting profile, and careful attention to detailing. Two sections are made especially for vertical cladding by UAM—with bold corrugations, and concealed fixing.

Asbestos-cement can be moulded into many forms. Variations include flutes, raised pyramids or diamonds. All the forms of asbestos-cement can be provided with colour finishes.

To end on a warm note: insulation. This can be a lightweight brick built behind the infill panels such as illustrated for Petrofina House, where insulation if 4 in of Thermalite. Otherwise there is the whole range of rigid and nonrigid insulations which can be incorporated into composite panels such as shown in the diagram. Air space is a good insulator, so are fibre glass and rock wool, compressed straw, woodwool, asbestos or vermiculite. Foamed plastics will be used more when they become cheaper. Finally foamed glass has been a frequent backing insulation in the United States.

Fireproof insulation of lightweight brick built on floor slabs in Petrofina House.



Plain Words

By Capricorn

LONG life is an outmoded virtue except in human lives. In engineering products of all kinds, early obsolescence is accepted as natural and unobjectionable. Armaments are, of course, notorious (the standard quip is that "if it works it's obsolescent"), but motor-cars and gas cookers and tape recorders—the lot—are all emulating the rabbits: a short life and a high rate of reproduction.

At home, early obsolescence and frequent renewals are normal practice. There is a continual drain on the family income to renew carpets, curtains, radio and television sets, heating appliances, or saucepans. The aristocratic families manage to retain their wealth partly because they are never so foolish as to buy cheap things. Their saucepans are of copper.

I was once shown round the store rooms at the seat of the Duke of Portland—Welbeck Abbey in Nottinghamshire—by one of His Grace's servants. The old man recalled with quiet pride the splendid sight before the First World War when the whole family, with relatives, friends and servants, set off in their special train for a holiday in Scotland. He showed me one of the minor relics of those holidays—a boy's model yacht, beautifully made and of good size, with a large carrying case lined with green baize in hollows shaped to take the model. Contrast this permanency of construction with the chromium plating on a modern motor-car, which cannot be left without attention beyond a few showers of rain.

The recent building by British Railways of their last steam locomotive is a reminder that long-lived machines are on the way out. In the United States, I am told, experience is showing that diesel locomotives have an average life that is appreciably shorter than had been assumed when "dieselisation" swept American railroads between the wars. A life of thirty years or more was common for steam locomotives, though only a few parts lasted the whole life.

Americans are certainly responsible for the concept of early obsolescence. When I was in New York I looked hard for some exception that might prove the rule; something that was built to last. Skyscrapers, I guessed. Surely even Americans wouldn't build a skyscraper on the early-scrapping principle. For a day I thought I had made a fundamental discovery about the American way of life. Then Mr. John Diebold, of computer fame, showed me round Wall Street, and pointed out the site of a former skyscraper, on which a bigger and better skyscraper was going up.

Americans or no, is early obsolescence a trick of accountancy, a super-fiddle based on the absurdities of tax laws? Is it a trick of the all-powerful salesman who can't sell unless he has something new in his bag? Or is it a trick of the engineer who can't design anything without finding after a few years that he could have designed it better?

Letters to the Editor

The Graduate Leaven in Industry

SIR, I was most interested in the articles which are currently appearing in ENGINEERING on the principal production centres of the United Kingdom. I have read the two articles covering Clydeside and the North East (ENGNG., 1 April '60, p. 446, and 8 April, '60, p. 478) and one outstanding thing struck me which I feel is worthy of more investigation and report.

On Clydeside the author, Mr. H. J. Novy, discovered that the management of industry had lost its vitality and the whole tone seemed to be one of losing a grip on the established industries of the area and grasping at uncertain chances arising from the establishment of new industries, some of which might appear very promising, but they may not be all they appear as a balm to the maladies of the older established industries. On the contrary, in the North East he found great optimism, energy and expectation.

What lies at the root of this difference?

I think Mr. Novy answered this question himself, at least in part, when he pointed out that Clydeside was not making adequate use of graduates in industry. He quoted figures which I forget but they were astonishingly low. In contrast I can only quote the employment of graduates by one of our nine subsidiaries—P.G. Engineering Limited—which employs 68 graduates in Stockton-on-Tees alone. I know that many other companies in the area have a strong reinforcement of this type of management and junior management and I can only think that the vitality of our area, which, as Mr. Novy says, is so very similar to Clydeside, can be attributed to the determination to keep abreast and ahead of every technical development affecting the future prosperity of our established industries.

I think that you can probably discover without a lot of difficulty what use the engineering industry is making of graduates and possibly show some of the results which can be achieved in contrast to the decay which must result from doing things as father did them.

Yours sincerely,
H. HOPWOOD,
Publicity Manager.

The Power-Gas Corporation Limited,
P.O. Box 21, Stockton-on-Tees.
12 April, 1960.

Buses in Lieu of Trains

SIR, Your correspondent Mr. B. M. Adkins, writing on "London's Traffic Termini" (ENGNG., 8 April, p. 472), appears to have missed the point of Brigadier T. I. Lloyd's letter on the "Need for a Review of Wheeled Traffic." It was evidently not Brigadier Lloyd's intention to compare the use of traffic channels by private cars with their use by trains.

His contention, however, that a traffic channel reserved for buses can carry more passengers in a given time than the same channel used by trains is supported by the operating experience of the two transport media. Whenever a train stops to put off or take on passengers it blocks the channel it occupies all the time it is stationary. Buses, on the other hand, can pull out of the traffic stream into lay-bys whenever they wish to stop. Consequently, whereas the maximum frequency which can be attained by a railway on each channel is one train every two minutes, the same channel used by buses could easily cope with ten buses a minute or more.

Furthermore, the use of buses instead of trains would greatly simplify terminal arrangements. Buses would enter a number of bays at one end of the terminal area and leave at the other, thus eliminating the need for reversing. If 60 seater buses were used, capable of being emptied and refilled in one minute, about the same number of bays would be required as there are platforms at present. Since, however, these bays could be shorter and narrower than the existing platforms the use of buses instead of trains would result in greater economy in the use of space at the termini.

Yours faithfully,
M. J. KEEDWELL.

19 Hoppingwood Avenue,
New Malden, Surrey.
13 April, 1960.

Government Research Grants

SIR, Your article "New Fields for Electrical Research" (ENGNG., 1 April '60, p. 467) has come to my attention. The statement concerning terms of government grant to research associations is unfortunately misleading. The principle at present followed in the case of our own Association is that the level of income contributed by industry to qualify for a given level of government grant is required to rise from time to time.

Yours truly,
E. E. HUTCHINGS,
Head of Member Relations Department.

The Electrical Research Association Laboratory,
Cleeve Road, Leatherhead.
13 April, 1960.

Educating the Engineer

SIR, Your admirable leader (ENGNG., 6 NOV. '59, p. 429) deals with a subject which has vexed the mind not only for years but almost for generations and Capricorn has commented upon the matter with his customary acumen (ENGNG., 27 Nov. '59, p. 526).

Perhaps too little recognition is given to the fact that the possession of a university degree or college diploma merely indicates that a foundation has been laid upon which the engineer may build up his engineering knowledge. The essential weakness of the present system of education lies in a lack of appreciation that engineering, or even any one branch, embraces a field so vast that no single person could possibly become proficient in the whole. It is the age of the specialist and this condition is likely to continue. Admittedly, however, some knowledge is essential of other areas of engineering outside one's own particular field.

During his course, therefore, the engineer should devote as much time as possible to the subjects which he wishes to practise rather than spend most of his time acquiring facts which he will promptly forget. To carry this sort of procedure into his final year at school merely robs him of the opportunity of becoming "educated."

The first essentials of a good engineer are that he must be able to think clearly and logically and must be able to express himself lucidly in well chosen terms. It is the duty of his school to equip him in this manner.

It must be confessed that serious problems are involved: the student must make up his mind at an early stage regarding the particular work he wishes to undertake. This may not be easy because, having completed his course, he may have to take any job which offers, but some latitude is permissible and an employer will give preference to a man having the knowledge which he wants.

Another, and perhaps more serious, difficulty is in the necessity for classes to be divided. This could only be achieved by increased finance either from the public purse or from higher fees. Governments, today, are becoming more conscious of the necessity to encourage education and to support universities and colleges, and, even if fees had to be increased, it is surely sounder economics to pay more in order to become efficient than to economise and waste half one's time. Furthermore, it would certainly be better to pay increased fees for three years than lower fees for four.

The undoubted fact remains that in almost every case a graduate promptly forgets some 85 per cent of what he has learnt at the university

and concentrates on replacing this by advanced knowledge in his chosen calling.

Yours faithfully,

GERALD B. LINCOLNE.

430 Little Collins Street,
Melbourne.
30 March, 1960.

Events in Advance

The World's Machine Tools on Show

UNLIKE other displays of machine tools staged in different parts of the world, the forthcoming International Machine Tool Exhibition in London will be international in the fullest sense. The event is being organised by the Machine Tool Trades Association and, provided that an importing member of that body holds an agency for a foreign machine, it may be shown irrespective of its country of origin.

The exhibition will be staged at Olympia, London, W14, from Saturday, 25 June, to Friday, 8 July, and will be a considerable increase in size over the previous exhibition in this series, which was held in 1956. Stand space in the various halls and galleries will provide an area of more than 287,000 sq. ft this year, compared with some 266,000 sq. ft on the previous occasion. A recent count showed that this year there will be at least 295 stands, distributed among 266 firms, compared with a total of 261 stands last time. Of the total number of exhibitors, 107 will be displaying British-built metal-cutting or metal-forming machine tools. Foreign machines will be shown on the stands of 45 importing members of the Association.

This year, the proportion of foreign machines to British is expected to be of the order of 40 per cent, compared with one of approximately 35·5 per cent in 1956. Foreign countries whose machines will be on show will include, in order of the number of machines expected to be displayed, Germany, Switzerland, the United States, Italy, France, Czechoslovakia, Sweden, Belgium, Denmark, Austria and Poland. The allied trades, producing heat-treatment furnaces, welding equipment, twist drills, milling cutters, small tools, grinding wheels, jigs and gauges, will be represented on the stands of some 95 exhibitors.

Inquiries regarding the exhibition should be addressed to the secretary, the Machine Tool Trades Association, Brettenham House, Lancaster Place, London, WC2. Telephone TEMple Bar 3606.

Exhibitions and Conferences

Inventory Planning and Control Course, First.—Sun., 19 June, to Sat., 25 June. Organised by the Industrial Management Center, Lake Placid Club, New York. Apply to Mr. James R. Bright, director, Industrial Management Center, 56 Robbins Road, Lexington, Mass., USA.

Sewage Purification, Annual Conference on.—Tues., 21 June, to Fri., 24 June, at Scarborough. Apply to the joint secretaries, the Institute of Sewage Purification, 10 Cromwell Place, South Kensington, London, SW7. Tel. KENsington 3885.

Physical, Chemical and Biological Methods in the Study of High Molecular Weight Carbohydrates.—Tues., 12 July, to Thurs., 14 July, in the Edinburgh and East of Scotland College of Agriculture, West Mains Road, Edinburgh 9. Registration fee, £1 15s. 0d. Organised by the Chemical Society, Burlington House, Piccadilly, London, W1. Tel. REGent 0675.

Mesucora: Exposition Internationale, Mesure, Controle, Régulation, Automatisme (58th Exhibition of the Société Française de Physique).—Tues., 9 May, to Wed., 17 May, 1961, at the Centre National des Industries et des Techniques, Paris. Offices: 20 Rue Carpeaux, Puteaux, Seine, France.

Photo Fair, International.—Mon., 29 May, to Sat., 3 June, 1961, at Olympia, London, W14. Apply to British Organisers Ltd., 52 Grafton Street, London, W1. Tel. EUSton 7930.

Electronic Engineering: Conference on Components and Materials Used in.—Mon., 12 June, to Sat., 17 June, 1961, at the Central Hall, Westminster, London, SW1. Organised by the Electronics and Communications Section of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Tel. COVent Garden 1871.

Plastics Exhibition and Convention, International (INTERPLAS).—Wed., 21 June, to Sat., 1 July, 1961, at Olympia, London, W14. Organised by *British Plastics*, Dorset House, Stamford Street, London, SE1. Tel. WATerloo 3333.

Packaging Exhibition, International.—Tues., 5 Sept., to Fri., 15 Sept., 1961, at Olympia, London, W14. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester 3. Tel. Deansgate 6363.

Factory Equipment, Heating, Ventilation and Thermal Insulation Exhibition.—Mon., 13 Nov., to Sat., 18 Nov., 1961, at Earl's Court, London, SW5. Organised by Industrial and Trade Fairs Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

Meetings and Papers

Association of Supervising Electrical Engineers

CROYDON
"Static Electricity in Industry," by S. J. Emerson. South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 28 April, 8 p.m.

British Institution of Radio Engineers

LONDON
"Education and Training of the Professional Radio and Electronics Engineer": Discussion. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Thurs., 28 April, 6.30 p.m.*

GLASGOW
Technical Film Display. Annual General Meeting. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. Thurs., 28 April, 6.30 p.m.

British Interplanetary Society

LONDON
"High Altitude Chambers and Pressure Suits," by Dr. E. W. Still. Hoare Memorial Hall, Church House, Great Smith Street, SW1. Thurs., 28 April, 7 p.m. (Tickets are required for this meeting.)

Chemical Society

CAMBRIDGE
"Some Applications of Mass Spectrometry in Organic Chemistry," by Dr. J. H. Beynon. Cambridge Branch. University Chemical Laboratory, Lensfield Road, Cambridge. Mon., 25 April, 5 p.m.

Illuminating Engineering Society

BIRMINGHAM
Film Evening. Birmingham Centre. Regent House, St. Phillip's Place, Colmore Row, Birmingham. Mon., 25 April, 6 p.m.

LEICESTER
Annual General Meeting. Leicester Centre. Offices of the East Midlands Electricity Board, Charles Street, Leicester. Mon., 25 April, 7 p.m.

Institute of Fuel

LONDON
Presidential Address. Institution of Civil Engineers, Great George Street, SW1. Wed., 27 April, 5.30 p.m.*

NOTTINGHAM
"Nuclear Power—The New Power Stations," by G. T. Shepherd. Annual General Meeting. East Midland Section. Offices of the East Midlands Gas Board, Nottingham. Thurs., 28 April, 6.15 p.m.

Institute of Information Scientists and Presentation of Technical Information Group

LONDON
"Scientists, Information Officers and This Writing Business": Discussion opened by Dr. B. C. Christian and J. B. Reed. Joint Meeting. College of Preceptors, 2 Bloomsbury Square, WC1. Thurs., 28 April, 6.15 p.m.*

Institute of Marine Engineers

BRISTOL
Films: "An Introduction to the Heat Engine"; "British Adventure"; and "Journey from the East." West of England Section. Small Engineering Lecture Theatre, University of Bristol, University Walk, Bristol 8. Mon., 25 April, 7.30 p.m.

Institute of Metals

LONDON
"Deformation and Fracture of Ionic Crystals," by Dr. J. Washburn, Associate Professor of Metallurgy in the University of California. Wed., 27 April, 6.30 p.m.

Institution of Civil Engineers

LONDON
"Design, Fabrication and Erection of the Ganga Bridge," by S. G. Savarkar, S. Turley, J. Williams and R. J. C. Tweed. Tues., 26 April, 5.30 p.m.*

Institution of Civil Engineers of Ireland

DUBLIN
Annual General Meeting. Mon., 2 May, 6.15 p.m.*

Institution of Electrical Engineers

LONDON
"Henri de France Colour Television System," by R. Chaste and P. Cassagne. Electronics and Communications Section. Wed., 27 April, 5.30 p.m.*
"Radar Observations of Birds and 'Angels'," by Dr. E. Eastwood. Thurs., 28 April, 5.30 p.m.*
"Planning and Installation of the Sound Broadcasting Headquarters for the British Broadcasting Corporation's Oversea and European Services," by F. Axon and O. H. Barron. Electronics and Communications Section. Mon., 2 May, 5.30 p.m.*

BELFAST
Annual General Meeting. Northern Ireland Centre. David Keir Building, Queen's University, Stranmillis Road, Belfast. Tues., 3 May, 6.30 p.m.

Institution of Engineering Designers

BRADFORD
Film Evening. Yorkshire Branch. Midland Hotel, Bradford. Wed., 27 April, 7.30 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
"High-Velocity Air Systems," by E. F. W. Cowell. Annual General Meeting. Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C2. Tues., 26 April, 7 p.m.

Institution of Mechanical Engineers

LONDON
Annual General Meeting; and Film Display, "The Rival World." Wed., 27 April, 6 p.m.*
"Papermaking," by T. J. Davies. London Graduates' Section. Thurs., 28 April, 6.30 p.m.*
"The High-Speed Heavy-Duty Diesel Engine: Its Development, Design and Application," by Dr. Ekhart Schmidt. James Clayton Lecture. Wed., 4 May, 6 p.m.*

BRISTOL
"Car Engines," by S. S. Tresilian. Western Automobile Division Centre. Royal Hotel, Bristol. Wed., 27 April, 6.45 p.m.

Institution of Plant Engineers

BIRMINGHAM
"Materials Handling: Fork Trucks, Maintenance, Repairs": Discussion. Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 29 April, 7.30 p.m.

CARDIFF
"Heating and Air Treatment in Industry," by A. A. Field. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 26 April, 7.30 p.m.

CHESTER
"Selection of Pumps": Discussion. Merseyside and North Wales Branch. The Blossoms, Chester. Thurs., 28 April, 7.15 p.m.

SHEFFIELD
"Mechanical Principles of Quarrying Equipment," by K. Holland. Sheffield Branch. Grand Hotel, Sheffield. Thurs., 28 April, 7.30 p.m.

Institution of Production Engineers

MANCHESTER
"Recent Developments in the Design and Construction of Ships," by R. V. Turner. North Western Region. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., 25 April, 6.30 p.m.

Junior Institution of Engineers

LONDON
"A Journey from Venice to Dubrovnik," by G. V. Rickards (illustrated). Fri., 29 April, 7 p.m.*

Reinforced Concrete Association

BRISTOL
"Precasting in Concrete Framed Construction," by J. F. Greinig and R. C. Westbrook. West of England Branch. New School of Engineering, The University, Bristol. Fri., 29 April, 6 p.m.*

Royal Statistical Society

SHEFFIELD
"Some Programmes on the Analysis of Experiments," by Dr. K. D. Tocher. Annual General Meeting. Sheffield Group. Grand Hotel, Sheffield. Thurs., 28 April, 7 p.m.

Society of Engineers

LONDON
"Problems in the Launching of Black Knight," by C. E. Tharratt. Geological Society, Burlington House, Piccadilly, W1. Mon., 2 May, 5.30 p.m.*

Society of Instrument Technology

LONDON
"Some Recent Advances in Industrial Electrical Control Techniques," by T. E. Barany. Annual General Meeting. Control Section. Manson House, 26 Portland Place, W1. Tues., 26 April, 6.15 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901)
British Interplanetary Society, 12 Bessborough Gardens, London, SW1. (TATe Gallery 9371)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W1. (LANgham 7124)
Institute of Information Scientists. Apply to Mr. J. Farradane, Torran, Croft Road, Orpington, Kent.
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Civil Engineers of Ireland, 35 Dawson Street, Dublin.
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Institution of Engineering Designers, 38 Portland Place, London, W1. (LANgham 8847)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786)
Presentation of Technical Information Group. Apply to Mr. B. C. Brookes, University College, London, Gower Street, WC1.
Reinforced Concrete Association, 94-98 Petty France, London, SW1. (ABBey 4504)
Royal Statistical Society, 21 Bentinck Street, London, W1. (WELbeck 7638)
Society of Engineers, Abbey House, Victoria Street, London, SW1. (ABBey 7244)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)

Road Surface Improvements

Skidding resistance and evenness are important factors in the selection of road surfaces. Brushed concrete provides these safe surfaces in a neutral colour with long life. Exposed aggregate finishes allow a variety of colours and textures to be used.

By D. R. Sharp B.Sc., M.I.C.E.

Cement and Concrete Association

THE average user judges roads by superficial criteria; in point of fact by their running surface. This aspect is only one of many which concerns the highway engineer, but he is paying more and more attention to it. As speeds and traffic intensities increase, so the safety aspect of the road surface is becoming more important. Many factors have an influence here, but the two most important are the skidding resistance and the evenness.

Almost all surfaces possess the same degree of skid resistance when they are dry, but when a film of moisture is present the picture is very different. Modern road surfaces are composed in part of natural stone, the grading of which varies from dust to between $\frac{1}{4}$ in and $1\frac{1}{2}$ in. The amount of the larger stones which is exposed is fairly small and recent research indicates that it is probably the particles of about $\frac{1}{16}$ in to $\frac{1}{16}$ in which are the most influential in their effect on the total skid resistance of a surface. The physical pattern of surface presented to the tyre also comes into the equation, but the whole story is not yet clear and active research is continuing. It has been established, however, that textures which allow water to drain away freely from the contact area between tyre and road surface are essential to reduce the risk of skidding to a minimum.

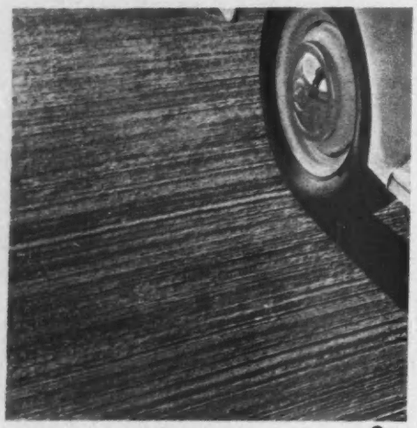


Fig. 1 An unworn brushed concrete road surface. The grooves run across the carriageway and facilitate drainage of surface water, in addition to presenting a highly skid-resistant surface.

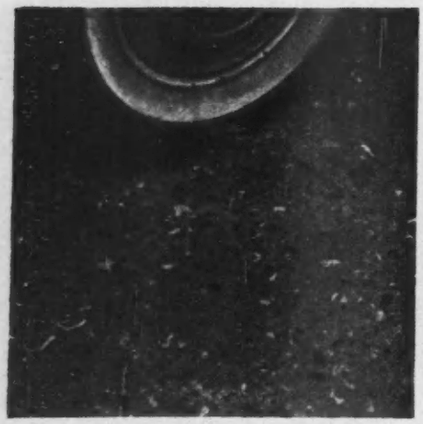


Fig. 2 An old well-worn concrete surface showing that the coarse aggregate particles make up a relatively small percentage of the area exposed.

For safe high speed movement a smooth surface is desirable so that full control of the vehicle can be maintained at all times. In this respect, long wave undulations are more dangerous than small scale bumps.

A light coloured surface which reflects as much as possible of the light falling on it is an advantage when driving at night or under bad weather conditions. This is true whether the driver is proceeding with the aid of his own headlights or in a well lit street, and arises because pedestrians and other objects are usually seen in silhouette rather than by direct illumination.

Large modern highways are dominant features in our landscape and the appearance of their surfaces, while it cannot be unobtrusive, can at least appear to be functional and as far as possible in sympathy. In this respect a uniform "neutral" colour is probably the best compromise. From the economic point of view a road surface should have a high resistance to wear, to weather and to accident which can, for example, result in chemicals coming in contact with it. Oil droppings are constantly being deposited upon road surfaces which should therefore be unaffected by this action.

BRUSHING AND SKID RESISTANCE

The last three factors all indicate that long life is a desirability in a road surface. This is additionally true for another important reason. It would conceivably be possible to develop a surface which was cheap and satisfactory in all respects, except that it required replacing at fairly frequent intervals. This policy might have been satisfactory 20 years ago, but now at least on most of our roads it would be against the national interest. It is only necessary to consider the catastrophic effect on the free flow of traffic of a small trench repair, to drive home how important it is that our road surfaces should have long, maintenance free lives.

Concrete running surfaces stand up well to all the criteria listed above. A characteristic quality of concrete is that it is highly plastic when laid and subsequently hardens quite quickly, which means that any desirable texture may be readily produced. It was at one time believed that a rough surface was necessary in order to obtain high skid resistance. For this reason concrete road surfaces were quite heavily ridged, but experience has shown that except on steep gradients this form of texture has no advantage and does, of course, result in a rough ride.

Almost all concrete surfaces in this country are now brushed, the coarseness of the ridging depending upon the choice of broom and the strength of application. A new, untrafficked, boldly ridged surface is shown in Fig. 1. In time the edges of the brush marks are smoothed down and eventually the brush marks may be obliterated altogether, although the rate of wear on a concrete surface is very small, being measured in only thousandths of an inch per year. The removal of the texture by wear seems to be disadvantageous. This is not so, however, because the removal of the ridges exposes the aggregate and the matrix of sand and cement which comprises the concrete. The skid resistance of the surface is then dependent upon the constituents of the mix which can be varied and controlled as experience and experiment dictate. Fig. 2 shows the texture of an old well-worn concrete road. In America the burlap drag surface, formed by dragging a piece of wet hessian over the surface, is commonly used. The effect is similar to brushing in so far as a thin film of cement and fine sand is removed from the surface, thus exposing a proportion of coarser aggregate particles and forming a physical pattern.

Fig. 3 A rough textured exposed aggregate concrete road surface. Smoother textures can be obtained by using smaller stone and less exposure.

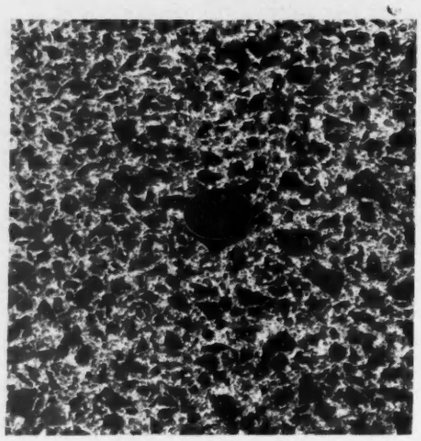


Fig. 4 An exposed aggregate concrete road surface, after considerable wear.

Some architects and engineers do not favour the natural colour of concrete for residential streets and use coloured additives in their mixes. In addition to a range of coloured cements such as buff, red and brown, it is readily possible to darken concrete using iron oxide compounds. The exact shade of grey can be readily varied to choice, though the darkening of concrete surfaces in this way is frowned upon by the street lighting and road safety engineer because it reduces one of the most important advantages of light coloured concrete road surfaces. Coloured concrete could, however, with advantage be used more widely for roads for delineating areas such as acceleration and de-acceleration lines, slip roads, lay bys and through routes from minor roads.

In a normal, worn concrete surface about 25 per cent of coarse aggregate is exposed. This proportion can be considerably increased resulting in a very attractive surface finish. The colour and texture can be varied to choice by using different types and sizes of aggregate such as red, green, grey, pink and purple granites,

Continued foot of next page

Prefabricated Steel Framed Buildings of Four Storeys

A new type of building produced by the Arcon Group enables, for the first time, structures of up to four storeys high to be erected by methods incorporating the latest of the group's techniques of prefabrication. The new structure is the Arcon Multiform, designed by A.M. Gear and Associates, consulting architects to the group, and marketed by Taylor Woodrow (Arcon) Limited of Welbeck Street, London.

The new building has been designed for use both at home and abroad for such buildings as schools, office blocks, hospitals and hotels. It could also be used for multi-storey factories for light industry.

The first Multiform is now in use as an office block, with ground and first floors, at Scunthorpe, Lincolnshire, for the United Steel Structural Company Limited, who belong to the group and who made the steel frame for the structure.

Bay sizes for the Multiform range from 20 ft by 8 ft to 24 ft by 12 ft, the planning grid being based on a 4 ft module. The standard ceiling height is 10 ft, thus permitting an adequate spread of daylight right to the backs of rooms.

The design of the building permits floors to be of either reinforced or prestressed concrete, precast or cast on site. For the roof, aluminium decking is recommended, but a concrete roof should be provided when it is necessary to allow for additional storeys at later dates.

Two types of walling systems have been designed for the buildings. One is a curtain wall made up of an aluminium alloy grid, and the other consists of large precast concrete panels with an exposed aggregate finish. Most types of standard internal partitioning can also be used, either of the permanent or moveable variety.

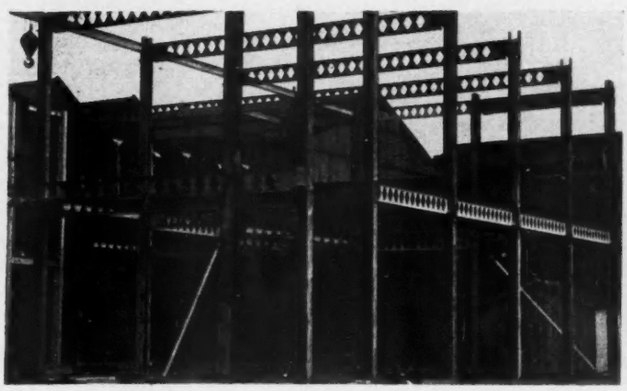
For the first Multiform building, the time taken from digging the foundations, which went down 10 ft, to occupation was 5½ months. The group believe that erection times of future buildings could be materially reduced.

The new Scunthorpe offices, with 6,280 sq. ft of floor, house the main reception area for the United Steel Structural Company's local establishment and other offices, including the main executive suite and conference rooms. The block is connected at first floor level by a bridge to the existing offices behind.

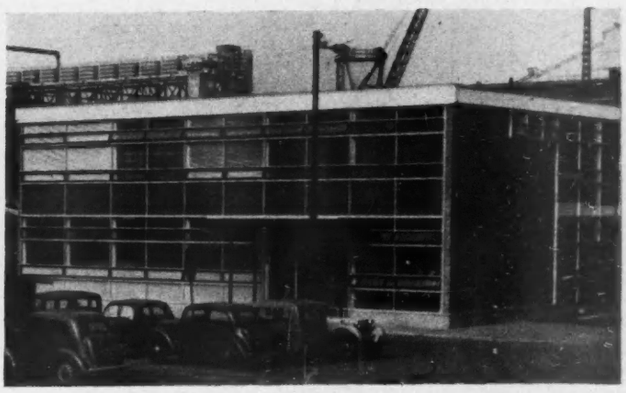
As this building was designed for future vertical expansion, the roof deck is of reinforced concrete, and the columns are already fitted with splice plates, so that additions will be made without disturbing the offices below.

The United Steel Companies are one of the founder members of the Arcon Group. Other members, each supplying the components in which they specialise, are the Crittall Manufacturing Company, ICI, and Stewarts and Lloyds, with Taylor Woodrow (Arcon) Limited as the marketing member for the United Kingdom, and Taylor Woodrow (Building Exports) Limited for overseas.

A prototype Multiform structure, incorporating ground and first floor, has also been erected at the group's development site at Southall, Middlesex, where customers can inspect the whole range of Arcon buildings.



The new Arcon building during construction, showing the use of castellated beams for the main framework of the Scunthorpe building.



Two walling systems are available. Light alloy curtain walling as on the front and of precast panels with exposed aggregate as on the side.

Concluding Road Surface Improvements

brown gravels, cream and grey limestones, grey, green and black basalts and white Derbyshire Spar. These special aggregates can be incorporated in the mix and then exposed by washing and brushing the surface, or they can be tamped into the plastic concrete surface in the clean dry state, and then re-exposed by washing and brushing. This process of re-exposure is quite simple to master with a little experience and the secret of success is to use a fine spray of water and to brush when the concrete has attained just the right amount of stiffness. Examples of road surfaces produced in this way are shown in Figs. 3 and 4.

Many textures additional to those mentioned above can be obtained in concrete but they are not applicable to road work. A somewhat different approach is to embed the stone chips into the concrete so that they are exposed only when the applied brushed texture is worn away. Fig. 5 shows $\frac{3}{16}$ in Leicestershire granite chips being applied by hand prior to being embedded below the concrete surface by a finisher.

One difficulty with concrete surfaces in the past has been that, if for any reason it was necessary to apply a new surface, a significant thickness of 3 in or more was necessary in order to provide a reliable repair. A close examination of the factors affecting bond between new and old concretes and the application of some new techniques such as acid cleaning, mechanical scaling and plastic adhesives, has enabled procedures to be evolved which enable quite thin layers of new concrete to be bonded to old slabs. There is no doubt that this aspect of the work will develop in the future and the cost, which at present is high, will be reduced. It can eventually be foreseen that new wearing surfaces to endow old concrete roads with new smooth-riding skid-resisting tops will be evolved. Mechanisation will enable this repair work to be carried out at high speed, with materials which set very quickly so that traffic can use the road almost immediately.

So far as surface finishes themselves are concerned, further experimental work into the factors affecting skid resistance will enable engineers to decide with more exactitude than at present the kind of surface which is most desirable, but it is fairly certain that whatever the requirements, concrete will be able to meet them. Improved methods of spreading aggregates and treatment of the concrete surface will result in better looking surfaces with good engineering properties.

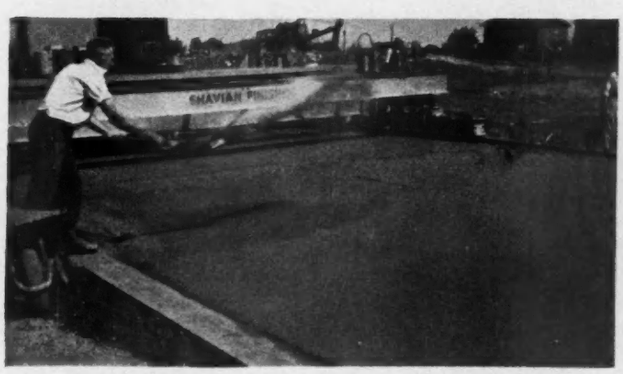


Fig. 5 Leicestershire granite chips ($\frac{3}{16}$ in) being spread on a plastic concrete surface prior to being embedded just below the surface by a mechanical finisher. The object of the process is to improve the skid resistance of the surface after the brushed finish has been worn away.

Hydraulics Departments for Universities?

By Dr. R. Silvester

Department of Civil Engineering, University of Western Australia

Existing departments of the engineering faculty, especially the civil and mechanical, depend to a great extent upon hydraulics and fluid mechanics. This dependency is so overwhelming that universities might well set up autonomous hydraulics departments.

Man's first attempts in community living almost certainly revolved around his ability to conserve and distribute water. This cooperative effort, now generally recognised as engineering, began a number of professional activities, such as land surveying and the determination of ownership problems, as well as many other facets of civilised life.

Although water can be made available fairly readily to almost all human beings and animals, it is still at a premium, mainly because of the demands of industry and agriculture. Vast sums must be invested in water facilities and brain power is in great demand to design them economically and to search for new supplies. It is enigmatic, therefore, that the channel through which science and engineering were born has not become a recognised part of the matured body of these professions. A certain amount of recognition is afforded by private bodies and some government departments, but, in the academic field, particularly within the British Commonwealth, the study of fluids has to fight for a place on the curriculum.

The first few years of an engineer's career, especially his university life, influences his outlook and appreciation of the various specialties and, where one of these is not present, or present only in dissected pieces within other departments, he is not easily attracted to it. This is, surely, the reason for the dearth of hydraulicians today.

The normal departments of an engineering school are civil, mechanical and electrical, and professional chairs in these branches are generally filled in that order. Later developments provide for departments in chemicals, metallurgy, mining, aeronautics, and so on. It is obvious that the study of fluids is involved in all these branches of engineering and it is submitted that an autonomous Department of Fluid Mechanics and Hydraulics could minister to the needs of these other departments, at all levels of their erudition, more effectively than they could do so themselves.

A COMPREHENSIVE FIELD

That the study of fluids is comprehensive and specialised enough to warrant separation from the civil and mechanical departments cannot be denied when the variety of its field is examined:

Flow in pipes and fittings	Industrial instrumentation
Fluid metering	Hydraulic servomechanisms
Waterways and channels	Film lubrication
Hydraulic machines	Fuel injection
Fluvial hydraulics	Heat transfer
Hydrology	Subsonic & supersonic flow
Model analysis	Ballistics
Flood control	Wind tunnel techniques
Irrigation	Transport of solids
Water supply	Ventilation
Chemical analysis of water	Surges and water hammer
Sewerage	Petroleum technology
Hydro-electric schemes	Rheology of lubricants
Coastal engineering	Naval architecture
Hydraulic structures	Meteorology
Urban drainage	Oceanography
Ground water flow	Corrosion
Public health engineering	Motion of sand and snow

It is worthy of note that, of the sixteen odd divisions making up the *Proceedings* of the American Society of Civil Engineers, six are directly concerned with hydraulic subjects while only four are associated with structures. Besides this, the *Transactions* of the American Society of Mechanical Engineers generally contain papers of which a third deal with hydraulics and fluid mechanics. This might be compared with the time in the curriculum spent on structures and hydraulics which is generally in the ratio of 2 : 1.

As mentioned earlier, the lack of recognition given to study of the fluid state has occurred mainly in the British Commonwealth. In Europe and the United States, departments of hydraulics and fluid mechanics exist in most universities. Also, large private and public institutions there are devoted solely to research in this field. It is fair to say that the greatest additions to hydraulic knowledge emanate from these countries at present.

In Britain, it must be admitted, several government-sponsored institutions exist which are associated with fluids, namely: the National Physical Laboratory, (Aerodynamics and Ship Divisions); Hydraulics Research Station, Wallingford; National Engineering Laboratory (Fluid Mechanics Division), East Kilbride; Water Pollution Research Laboratory, Stevenage; British Hydromechanics Research Association Laboratory, Harlow; National Institute of Oceanography, Wormley; and the Admiralty Underwater Hydrodynamics Laboratory, Teddington.

Even so, there seems to be only one Chair of Fluid Mechanics and Hydraulics in Britain—at Imperial College, London—and this has been created within the College's department of civil engineering. One or two other departments of fluids exist, but chairs have not been created in them.

ADVANTAGES

Before discussing the manner in which new departments should be created it is expedient to study in more detail the advantages accruing from a completely autonomous Department of Fluid Mechanics and Hydraulics; a better name for this might be Department of Fluids.

For one thing, personnel would be attracted from the civil and mechanical branches. With their differing backgrounds and experiences they would nurture and fertilise each others' research programmes. The problems, as well as the solutions, of the one would become known more readily to the other.

The subject of fluid mechanics would attract the mathematician and theoretical physicist who may become attached to the staff of the engineering school. Such a result would make for better mathematics teaching and provide a closer relationship with the mathematics department.

Again, the fluid mechanics and hydraulic units of engineering degrees would emanate from an integral body of lecturers under one professor, who would be of equal standing to his civil and mechanical colleagues. All basic flow equipment would be located to show a unity of theory and application throughout all realms of undergraduate teaching. Service courses to students, both outside and inside the engineering faculty would be more effectively organised. A greater choice of subjects would be available to undergraduates during the latter stages of their course, instead of the sharp divisions which at present occur in the existing civil-mechanical-electrical arrangement. Combinations of subjects could be envisaged which would make engineers better equipped for the aeronautical, petroleum and hydro-electric fields, three important vocations today.

The advantages to fluid engineering of having one administrative head need not be laboured. The head of the department would be able to press for equipment, staff and space, together with the rest. The demands for space and equipment for this field of study are rather unique in that it must be integrated if facilities are to be provided economically. Unification under one head would help in ministering to the needs of other departments regarding questions of fluid metering, pumping and other such matters, which concern nearly all natural and applied science faculties.

Advance in any field of endeavour depends, in the short run, upon research; in the long run, it depends too upon the brain power attracted to it. In this regard, the incentives of remuneration and status can only be provided by the creation of chairs in the subject. Until such zenithal positions are available, men are going to be deflected to other fields where such avenues of promotion exist. Professors of civil engineering in the British Commonwealth are notoriously structural engineers. The two or three with hydraulics backgrounds have fought an uphill battle against tradition and professional "nepotism."

METHOD OF DIVISION

The question immediately arises that, if a department of fluids were to be formed, why not departments in all subjects? Well, why not? What shining advantages are there in the present traditional trio of civil, mechanical and electrical? The civil engineering department should be given a more appropriate name anyway, perhaps "constructional engineering."

It may be that the traditional trio has been retained because of the three main professional Institutions associated with them. Some peculiar breeds of engineer find that they must belong to two of these in order to fulfil their vocational obligations. On the other hand, the medical profession does not restrict its schools to three departments because it has Royal Colleges of Physicians, Obstetricians and Gynaecologists, and Surgeons. A newly-formed Medical School today would consist of nine or ten departments, and a functional division of engineering along similar lines might comprise initially: communications, control systems, electrical power, fluids, machine design, materials, mechanics, soils, structures, surveying, and thermodynamics.

There need be little argument about the desirability of such an end result, but the method of achieving it is debatable. If existing departments and chairs were to be thrown into the melting pot for the purposes of subdivision, many personal and institutional problems would arise. University authorities presented with a bill for eleven new departments, where three existed previously would undoubtedly present formidable barriers to it. Again, the engineering Institutions have not the same control and influence over the profession as has the British Medical Association over the medical profession.

It seems apparent, therefore, that multiplication of departments in engineering schools must take place slowly, perhaps when the retirement of existing professors takes place and at other opportune times. But to provide the precedent and the stimulus, one or two departments should be set up alongside the present trio, which in their strength, it is sad to relate, generally fight for greater power rather than live amicably as would a larger family. In this context, are not fluids renowned for their lubricating properties?

It is submitted that fluids, at present the poor sister of civil and mechanical engineering, has a worthy case for being first in line in this expansion. Such a move would serve as a very good precedent. But first, the profession must discuss the pros and cons and become united regarding the goals to be achieved and the mode of achievement. Even hydraulicians seem rather divided on the matter; mainly about the opportune time for such developments. It is hoped that this article will encourage discussion and comment from all sides of the engineering faculty.

Human Element

What Becomes of Design Bursary Winners?

Over half the bursary winners in the Royal Society of Arts Industrial Art Competitions from 1946 to 1958 are now fully employed as industrial designers or in full time private practice as free-lance designers or consultants.

The survey of past winners, 193 in number, of whom information on only three was not forthcoming, is reported in the RSA's results of the 1959 competitions.

From the 193 winners of the 212 bursaries, worth £26,025 together, 101 70 men (and 31 women) are now full-time industrial designers.

Thirty (4 men and 26 women—16 of them married) are now employed as part-time designers, 14 of them combining part-time designing with full-time school teaching.

Twenty-one (5 men and 16 women) are full-time teachers, 14 of them doing part-time designing.

The one male bursary winner who has moved into non-design employment has become national general secretary of his trade union.

Salary data was given by 84 of the bursary winners. Thirty three of them were now earning over £1,000 a year and 23 less than £750.

The 1959 competition had 653 candidates (495 in 1958) from 81 schools and industrial establishments. The number of schools and establishments sending in candidates was only one more than in 1958. Thirty four bursaries, worth £4,425 were awarded in 1958, the bursaries (25) were worth £3,300.

The ETU Must Try Again

On the face of it, the Electrical Trades Union retort to the Trades Union Congress, that it could not give a decision for or against a judicially led inquiry into its affairs, appeared sufficient. The executive advanced the reason that as its former education officer, Mr. Les Cannon, was contemplating legal action for the restoration of his union rights, the whole matter was *sub judice* and could not properly be the subject of an inquiry.

On the day that this appeared in the papers Mr. Cannon spoke to his solicitor and put the ball neatly back on the executive's side of the net by proposing to withdraw any legal action of his own if the union would agree to a judicial inquiry.

On Monday (25 April) the TUC's ultimatum expires. That is the date by which the ETU executive has to accept either an inquiry into the conduct of its activities, and especially elections, or start legal action for redress against those whose statements appear to be defamatory.

If it does neither it could be suspended from membership. Suspension of a militant union like the ETU would be a rather bolder step than the TUC council has dared in many years. There is no doubt that in some quarters the ETU has a reputation for "getting results." If they were to wake up one fine summer morning and find themselves suspended the executive might soon have to decide whether to admit to membership the workers of other unions brought in by the more active branch members.

The regular meetings of the TUC committees are spaced far apart. It would be very easy to keep this pot boiling until the congress in September, when the decision could be taken by majority vote. And the majority would be responsible for the consequences.

Ernest Bevin and Oliver Cromwell

A few short years after the death of Oliver Cromwell the Commonwealth had been torn down and Charles II placed on the throne.

Ernest Bevin was no regicide, though the way in which he destroyed the political life of George Lansbury was not lacking in brutality. The comparison arises in the question whether anyone since Bevin has been in control of his giant and sprawling creation, the Transport and General Workers Union.

The two great creations of Ernest Bevin were his union and the North Atlantic Treaty Organisation. The story that Alan Bullock tells in *The Life and Times of Ernest Bevin*, Volume One, published by Heinemann, 50*s*, is of Bevin's formative years, of the formation step by step of the T & GW, and of its activities and Bevin's until the Second World War took the future Foreign Secretary into the Churchill Cabinet as Minister of Labour.

That the T & GW did not fall apart under the eroding jealousies and genuine difficulties was due directly to Bevin. He had a rare blend of direct experience of working men added to organising ability of the first order.

The direct control of the many trades that make up the largest union in the world is kept in the hands of the men from those occupations by fourteen national trade groups. At the same time each section lends its strength to the others through the thirteen regions, each of which has a regional office and secretary.

This two-tier system, worked out by Bevin while he was travelling hundreds of miles a week in third class railway carriages and speaking in appeals and negotiations during the day, almost certainly kept the union together when its first trials came along in the early 1920's.

At the union's centre sits the elected-for-life general secretary. After Bevin it was Arthur Deakin, a man on the far right wing of Labour, much of whose period of office was marked by a time when the leadership of the London dockers was in other hands than the union. The man at the centre now, Mr. Frank Cousins, certainly does not lack the courage and the ability to walk into a mass meeting of abusive members taking part in a misguided unofficial strike and argue them into voting for a return to work.

He has a more complicated relationship with his colleagues in the council of the Trades Union Congress than his predecessors. To the left rather than to the right of the Socialist spectrum he is deeply concerned with contemporary dilemmas like nuclear weapons, just as Ernest Bevin was passionately indignant at the poverty of his times.

The Transport and General has something of the appearance of a self-contained TUC for all the trades within it. Wielding a power not given to the officials of the TUC, the general secretary of the T & GW is committed to a vast amount of detailed consideration of subjects arising throughout industry. Ernest Bevin, as now Frank Cousins, found no difficulty in discharging these duties and contributing to the political life of the time.

The bitter fight Bevin took part in to achieve national negotiations, and his struggle to get wages up to the breadline in the ports, are part of the history of the United Kingdom. The second of Alan Bullock's volumes will deal with Bevin's period as a Cabinet Minister, including the contribution his experience at the International Labour Organisation made to his years as Foreign Secretary.

Trade Union Command of the Labour Party?

The most important event in the Labour movement since the loss of the last election may be the election of Mr. Harry Nicholas as Treasurer. For Mr. Nicholas is assistant general secretary of the largest of all unions, the Transport and General Workers.

In order to play a complete part in the government of the nation the Labour Party must be a national and not sectional organisation. But the trade unions are part of the constitutional functioning of the Labour Party. Hundreds of faces that appear at the autumn convention of the Trade Union Congress also appear, and vote, at the annual conference of the Labour Party.

No employers organisation has voting rights at the Conservative annual meeting. If a prominent leader of the Institute of Directors were to be seen making a particular contribution at one of these annual deliberations uproar from the other side would swiftly follow.

That Mr. Nicholas, who has always been especially associated with the transport union's engineering members, should be put forward for the treasurer's job is one more indication of the desire in some union circles for a greater influence over the workings of the party. Another sign was the recent rejection of the official nominee and the substitution of a former rail union leader to lead the party's group watching transport developments.

Mr. Nicholas, a calm and reasonable man with a reputation for efficiency in negotiations, has a degree of experience that puts his capacity beyond question. Regrettably an election of this nature is not concerned with personal abilities.

If in the end the post goes to a member of the Parliamentary Labour Party the influence of the union chiefs on the party's high command will not have gone unnoticed.

A Striking Similarity in European Wages

The proposition that British and German workers earn almost exactly the same, taken on average, and that the French are only a few (heavy) francs behind would get short shrift from most superficial observers in this country.

But a study conducted by the French National Statistical Institute suggests that this is exactly the case.

In April, 1959, says the Institute, the average payment per man-hour (welfare charges added in) was, in descending order, Western Germany 5*s* 7*d*, the United Kingdom 5*s* 6*d*, France 5*s* 1*d*. Well behind were the rates in Holland 4*s* 1*d* and Italy 4*s* 4*d*. Cost of living levels make a great deal of difference to the effect of these earnings and social benefits. On recent figures the average hours worked in British industry are sufficiently greater than those in Germany to make another sharp change.

Morale is a Management Responsibility

Mr. R. R. Hopkins, the personnel and welfare manager of Vauxhall Motors, of Luton, speaks on personnel problems with the authority of one who comes from a motor plant that has managed to avoid the uproarious history of its major competitors.

But the views he expressed to the British Institute of Management's Midland Management conference at Leamington Spa might well not find complete agreement with some other leaders in this field.

Vauxhall's overall policy, which in a television programme once appeared to enjoy the benefit of unusually high participation by the men in management decisions, was defined by Mr. Hopkins under two heads. They were the maintenance of wage levels better, on average, than those in the immediate locality, but not greatly so, and the provision of employee benefit programmes that could stand comparison with those offered by the leading firms in the country

If this covered the whole essence of Vauxhall's policy it might be that the first malcontent who got up and promised to get the men higher wages, or better fringe benefits could lead them into a strike.

Nigel Balchin once write that the secret of good labour relations does not lie solely in devising a perfectly fitted-out factory with high wages—a kind of splendid cow shed. If the problem is regarded in a material way only then the management's hand will always be outbidden.

Participation, a chance to act responsibly and to be recognised as capable of doing so are perhaps more of the essence of good working relationships. Something of this is seen in the steel industry where high wages are earned, as in the car plants, but where a worker is more likely to have to use his initiative, and where good industrial relations are a legend.

Vauxhall's Mr. Hopkins effectively attacked two ancient platitudes when he said it is not enough to treat people as you wish to be treated yourself, nor to regard morale as the outcome of applied common sense.

On the pattern of wage structure the important targets were that it should be a clear uncomplicated system offering the greatest opportunities for advance on merit. The employee benefits had to be looked at simultaneously in two ways: one eye on what was being done in the rest of industry, the other on the specific needs of the employees.

The management, said Mr. Hopkins, must accept full responsibility for the morale of an industrial organisation. And it is no good concentrating on the morale of the rank and file. Their morale will inevitably be no better than that of the management group itself.

Engineering Growth in Yorkshire

There can be few areas in Britain which have such a complete spread of engineering activities as the industrial areas of Yorkshire, or which show such healthy signs of future development.

By H. J. Novy

For his fourth article Mr. Novy reports on Yorkshire industry.

Last week he dealt with Northern Ireland. Next week: the Merseyside.

THE industrial roots of Yorkshire lie deep in its four million acres of land, beautifully served by natural waterways and rich in mineral wealth. Originally it was the ideal sheep breeding conditions which fostered the growth of woollens in the area and it was the need to clip the sheep's wool which fostered the growth of an industry making knife blades, shears and other edge tools.

The coalfields of Barnsley and Doncaster, first exploited by the monks of Beauchief and Pontefract in the 13th Century, provided the basic raw material required to process the ironstone found in the Rotherham-Dewsbury district, although charcoal was first used. Abundant water power permitted the use of mechanical bellows for the first cupolas and the driving of mechanical hammers and grinding wheels, long before steam power was introduced.

Good material for making grindstones was also close to hand, and the good waterways available made it possible to import at low cost higher quality iron ore and finer varieties of steel, mainly from Spain, Russia and Sweden. The relative ease with which such materials could be brought to Sheffield, through Hull and by river to Bawtry, was one of the factors which enabled the region to become the leading centre of tool manufacture in Britain.

A scientific and historical survey of Sheffield and its region published by the British Association for the Advancement of Science in 1956, states that the industry "was expanding from the late sixteenth century onwards and when, in the eighteenth century, Sheffield had the advantage of an excellent steel locally produced and good craftsmen to use it, the region rapidly became the predominant centre of the cutlery trade."

The basic industries of Yorkshire—which, for the purpose of this article, excludes North Riding—were therefore woollens and cutlery. The availability of iron ore and lead ore played an important part in enabling the industrys' growth to proceed quickly but were not a dominant factor in shaping it.

The treatment, spinning and weaving of wool gave rise to ancillary industries to supply its needs, which included machinery and dyestuffs, and the availability of woollens led to the establishment of a clothing industry which is now one of the leading employers of labour. The skills and materials developed in the making of edge tools likewise led to the establishment of ancillary activities: rolls and forges for the processing of alloy steels, and allied industries such as die making, the manufacture of nails, pins, gears, and other "hard" steel products, machine tools, gears, crushing machinery, etc.

Another factor in the industrial development of the region has been the outstanding richness of its agriculture. Timber resources led to the establishment of an important wood processing industry and its agricultural produce to that of a food processing industry which later spread into drink manufacture and gave rise to a major bottle-making industry.

DIVERSITY

The most striking feature of the region today is the considerable diversity of its industry, most of which is concentrated in the west and south. Its population is one of the least crowded. Its large towns—Sheffield, Leeds and Bradford—account for only 32 per cent of the total population, and the conurbation of West Yorkshire, which is the main area of urban development, for just over 42 per cent. There is certainly less overcrowding than in most other industrial areas in the country.

The growth over the past 47 years has been modest: by 98,000 in the conurbation of West Yorkshire and 570,000 in the region as a whole—an overall increase of about 15 per cent during the period compared with 25 per cent for England and Wales. In this relatively slow growth lies the region's major problem—a shortage of manpower.

Three industries are substantially above the national average of employment: textiles, which account for nearly 23 per cent of the United Kingdom's employment in textiles of all kinds, and for 11½ per cent of employment in the region; mining, with 17 per cent and 8 per cent respectively; and metal manufacture with 16 per cent and 5 per cent.

Unemployment in the region as a whole is very low: in 1959 the monthly average was 1·9 per cent, compared with 2·3 for the UK as a whole. A shortage of labour has developed in recent months in the West Riding industrial centres. Textile firms in Barnsley, for example, find it impossible to recruit sufficient labour although coach loads of Barnsley girls depart each morning for work in Leeds and Bradford. In Leeds there has been some importation of foreign labour, mainly from Italy and Pakistan.

WOOLLENS

Three-quarters of Britain's woollen industry is located in West Yorkshire, in the areas of Bradford, Halifax, Huddersfield and Leeds, where it competes for labour with a most active engineering industry. The finished cloth is one of Britain's leading exports, amounting in 1959 to more than £60 million, and the industry is prosperous and vital. Net output, which is the value added by manufacture and excludes the cost of materials, totalled £150 million in 1954 and is likely to have topped £200 million last year.

Despite its excellent and remarkably consistent performance the woollen industry is far from being self-satisfied. The twin problems of labour shortage and the development of man-made fibres which compete with wool, such as Terylene, have produced a substantial research programme. The Wool Industries Research Association at Torridon employ an impressive number of scientists and the industry enjoys a world lead in the field of wool technology and machinery.

Solutions to the shortage of labour are being sought in the development of high-speed automatic machinery. The new Bradford system of worsted spinning and the Ambler Superdraft spinning method are splendid examples of the advances the industry has made in recent years. A great deal of research is also being carried out at Torridon on finding new uses for wool fibres and on the blending of wool with man-made fibres. At Leeds University the department of textiles, headed by Professor J. B. Speakman, who is one of the world's foremost experts on wool, has created a new department for research into man-made fibres.

SMALL FIRMS

Wool manufacturers are well aware that to meet successfully the growing competition in the wool textile markets of the world, extensive re-equipment must be undertaken on the greatest possible scale. One of the difficulties lies in the fact that the industry is made up of a large number of small production units—in 1954 there were 1,875 of them, employing an average of only 108 workers each. The extensive mechanical and technological changes required to reduce production costs and improve quality are very costly and it is likely therefore that many of the smaller concerns will become associated with the larger units.

In close proximity to the woollen mills, mainly in the Leeds area, there exists a large clothing industry using mainly woollen and worsted cloths. Like the wool industry it consists of a relatively large number of small establishments, employing mainly female labour. In 1954 the average employment per firm was less than 100 and net output amounted to £24 million. Although capital investment has been low (this is of course anything but a capital-intensive industry, using mainly shearing and sewing machines) some expansion has taken place over the past decade. Employment is currently believed to exceed 70,000, compared to 61,700 in 1951, and the industry is confident that it can do even better. Extensions to capacity, however, have been relatively very small since the war.

Yorkshire is fortunate in both its coal and steel industries. Coal mining, located in the south west—Doncaster-Barnsley area—has suffered rather less than the industry as a whole, and is probably the richest and most productive in the country. Nonetheless there is no apathy in the coal producing area. Output has been maintained at a steady level and the only restrictive measure imposed so far has been the stopping of recruitment of adult labour.

One of the oldest industries in South Yorkshire which is still growing is glass manufacture. One of the three large firms in the area, Redfearn Brothers, produce nearly one third of the bottles used in the soft drinks industry and another—Wood Brothers Glass Company—make most of the glass required for headlamps on motor cars. A subsidiary of this company have developed the manufacture of tiny glass nodules for mixing with the paint used to mark road lines.

Despite these developments, there is a feeling in South Yorkshire that the Government might do more to help the introduction of new industry into the area. There is a realisation that self-help must, to a major extent, be the order of the day and there has been set up the Association of Yorkshire Chambers of Commerce to look into the development of new industries in the area.

The initiative taken by the Chambers of Commerce is certainly a step in the right direction. With a little determination and moderate expenditure on research it could well produce the first plan for regional development in the whole country, thereby doing away with the half-hearted remedial action and carrot dangling which has characterised the Government's efforts in development areas. Should it produce a new outlook on the planning of an area's industry, as it promises to do, the absence of Government help could be a positive advantage.

CUTTING STEELS

The steel industry of Yorkshire arose to supply high quality materials for the cutlery trade in the area. Although the latter now takes only a small portion of the steel makers' output, hard cutting steels have remained the essential product of the firms in the Sheffield-Rotherham area.

The Firth College and, from 1905 onwards, the University of Sheffield, produced outstanding men whom the steel firms of the area were quick

to engage to work in their own research laboratories. This factor—the early introduction of scientists into steel-making—doubtless the main factor in Sheffield's pre-eminence today.

In 1948 some 83,000 people were employed in the manufacture of metals in the region, and net output was £50 million; six years later the labour force had increased to 87,300 and net output to £80 million. Since then employment has risen by a further 3,000 and net output is likely to exceed £100 million. Nearly 5 per cent of the whole region's working population was employed in the steel works. The largest steel manufacturers in Britain, the United Steel Companies, have their head office in Sheffield, from which they control and integrate the activities of Samuel Fox and Company in Deepcar and Steel, Peech and Tozer in Rotherham, as well as other companies outside the region. Apart from being one of the largest, it is also one of the most research minded companies in British industry, and conscious of the need for continuous change in every aspect of product policy. Edgar Allen, Brown Bayley Steels, John Baker and Bessemer, English Steel Corporation, Thos. Firth and John Brown Hadfields, Arthur Lee, Samuel Osborn, and Firth-Vickers are among the main Sheffield steelmakers. Most of them have developed on modern lines by investing heavily in new techniques and equipment.

A characteristic of Sheffield's steel industry is the sharp contrast between large and small units. In 1954 there were 146 establishments melting or rolling steel, many of them very small and using techniques developed in the last century. They still rely mainly on crucibles for melting and on human judgment for the quality of their products. It is this type of firm which is equipped to supply variety at relatively low cost. When it is borne in mind that a works employing 200 men may well be supplying as many as 2,000 customers with a product which could not be obtained elsewhere, then the function of much of Sheffield's industry is seen in the right perspective.

The steel industry in the Sheffield area has added some 5 million sq. ft to its works area since 1945. This is an expansion exceeded only in South Wales and in the Midlands. One of the latest major developments to be approved is a £15 million scheme for the English Steel Corporation. The industry's re-equipment and the adoption of the newer techniques of production will doubtless have to be hastened, since the market for alloy steels has become highly competitive—after being in short supply for almost a decade. Competition has developed recently from France and Italy, as well as from Germany and Sweden, and the possibility of being excluded from the Common Market is being taken very seriously by the industry.

CUTLERY

Cutlery was the base of Sheffield's growth for many centuries, and until quite recently its manufacture still retained many characteristics of a cottage industry. Ninety eight per cent of Britain's cutlery is made in Sheffield, and when you look at the maker's mark on a Sheffield knife it may be any one of more than a hundred names, but the chances are that it will be one of about a dozen. Although some 6,000 Sheffield people work in cutlery, fewer than twenty firms have more than fifty employees.

However, we are witnessing the gradual disappearance of these tiny, one or two man firms, or "Little Mesters" as they are known. Each man, often working in a tiny back room, was responsible for one process, and only one, and the cutlery was passed from "mester" to "mester" as each process was completed. Hopelessly uneconomic—it used to be said that at any given moment, more cutlery was en route from one mester to another than was being worked upon—the system is gradually being replaced by mass production and modern design, without a corresponding decline in craftsmanship.

It is a fair comment that in the past—the very recent past—Sheffield, while no one disputed the quality of its cutlery, tended to ignore the demands of style and design. The growing import of Scandinavian cutlery with its elegance and clean lines has made a great impression on the English makers, and cutlers have been compelled to fight for their markets.

One of the foremost designers, Peter Inchbald, joined his family firm only 5 years ago, when all the directors were over 60, and there was talk of selling out. Now the four executive directors are all less than 45, and Inchbald has introduced entirely new designs. Although an uphill battle, the first steps have been successful, mainly because the customer was in advance of the shopkeeper and his buyer, and liked the new designs. Management consultants have been brought in, and the first moving belt has been installed. The number of different articles made was reduced to 1,000 from 7,000.

Engineering (in the narrow sense used by the Board of Trade classification) is the second largest industry in Yorkshire, with 149,000 employees, compared to 211,800 in textiles and 146,000 in coal mining. There is, however, a bewildering variety of activities, as is shown in the Table.

It is an industry I know well, but one which is difficult to discuss adequately without going into considerable detail. There are at least 1,900 firms in the region manufacturing engineering products, and the average employment is less than 80. I have indicated earlier that many of the engineering firms came into being to supply the area's basic industries, such as Davy and United, Brightside Foundry and Engineering, and Newton Chambers, who make steel works plant; Fairbairn Lawson Combe Barbour, Card Clothing and Belting, Greenwood and Batley, G. Hattersley and Sons, Sellers and Company, and many others who supply the woollen industry with specialised machines and accessories.

Another group of firms came into being to supply the coal industry, such as Cementation, British Jeffrey-Diamond, Hardypick, etc. Others based themselves in the area because of the ready availability of the special steel or the special skills needed. They include the whole of the small tool and implement trade, closely allied to the cutlery industry and as long established, and a strong concentration of machine tool manufacturers in the Halifax and Huddersfield area.

Employment and Output of Engineering Industries in 1954

Industry	No. of establishments	Net output	Total employment
Shipbuilding and ship repairing	49	4,416	5,929
Machine tools	117	15,822	18,429
Textile machinery and accessories	115	8,473	11,532
Constructional engineering	42	3,305	3,670
Mechanical handling equipment	23	1,714	1,877
Printing and bookbinding machinery	13	1,841	2,730
Mechanical engineering (general)	346	46,863	57,080
Mechanical engineering (repairing)	96	3,021	3,762
Electrical engineering (general)	76	13,049	18,114
Radio and telecommunications	18	2,287	3,818
Motor vehicles and cycles (manufacturing)	56	15,658	17,867
Motor vehicles and cycles (repairing)	144	3,068	5,865
Railway locomotive shops and locomotive manufacturing	41	3,990	6,673
Railway carriages and wagons and trams	80	7,879	13,002
Tools and implements	100	6,415	9,873
Cutlery	102	3,630	6,680
Chain, nail, screw and miscellaneous forgings	64	5,501	7,256
Wire and wire manufactures	61	6,160	7,696
Hardware, hollow-ware, metal furniture and sheet metal	144	8,874	12,541
Brass manufactures	41	3,132	3,778
Scientific, surgical and photographic instruments, etc.	44	3,152	4,167
Jewellery and plate	62	2,793	5,848

Such famous firms as William Asquith, David Brown, Dean, Smith and Grace, J. Sagar and Company, all began their life in the region. Some of them, such as David Brown, make gears and have considerably diversified in other fields including motor vehicles, agricultural tractors and atomic plant. Manufacturers of prime movers, particularly electric motors, also abound, led by Brook Motors in Huddersfield and Crompton Parkinson in Guiseley. A progressive hydraulics industry based on Leeds includes Henry Berry and Towler Brothers. Hopkinsons make valves in Huddersfield. Hudswell, Clarke and Company and Hunslet Engine Company make mine and other locomotives in Leeds.

There can be few areas in Britain which provide so complete a spread of engineering activities. Expansion has been rapid since the war. Factory space has been increased by 6½ million sq. ft in the period 1945-58. In general, therefore, the picture is one of considerable resilience and activity.

The manner in which Ada (Halifax) Limited added domestic washing machines to their range of machine tools and became one of the leading producers in the country in a few years is an outstanding achievement, but not untypical of the enterprise and spirit of engineering firms in South Yorkshire.

Although some 50 miles from the east coast, the West Riding has its own port—Goole, lying at the mouth of the Ouse. Goole possesses a surprisingly comprehensive docks system—a system upon which much responsibility will rest in the future, with the increase of trade due to the Outer Seven proposals. Goole and Hull, in fact, are ideally situated for trade with the Scandinavian countries.

RAILWAY AND MOTORWAY

Over the West and East Ridings, communications are in general now good, particularly with the electrification of the Sheffield-Manchester railway line, which has almost doubled the volume of goods traffic, quite apart from the saving of time. As other lines are electrified in the area, and with the advent of the London-Yorkshire motorway, we may look for an ever increasing volume of traffic to and from Yorkshire. As yet, though, Sheffield has no airport and inadequate hotel accommodation for trade visitors.

Yorkshire folk have a forthrightness and independence of character and are intensely "region-conscious." Labour relations are on the whole excellent, particularly in Sheffield where the very high proportion of skilled and time-served men results in a remarkable absence of overseers.

Traditionally the iron and steel industry has relied on the skill of teams of operatives, but a change of emphasis is becoming evident. The increase in instrumentation and the installation of electronic and other automatic controls—in which Sheffield has been a leader—has to some extent removed, as a production factor, the personal judgment of the operative and a new type of skill will be needed in the future.

More highly trained technicians for plant maintenance will also be required, but past experience has shown that the manual workers are highly adaptable and quick to acquire new techniques without affecting good labour relations. Sheffield has been fortunate in that it has been the scene of dramatic discoveries in the making of steel.

Overall there is a refreshing willingness to face up to problems, much as one might expect from a people so intensely blunt and forthright. There is a readiness to look at problems, not only that are with us now, but which might conceivably arise in the future. The picture is one of abounding confidence and stern determination.

DIGITAL COMPUTER

For General Use

THE RPC-4000 is a fully transistorised digital computer for use on general office or enginering work. It will be available in this country shortly.

The machine has a memory of 8,008 words which can be scanned at a rate of nearly 200,000 a minute. A special masking feature allows partial words to be scanned at the same rate. Three thousand words of memory can be scanned in less than one second for full or partial equality or for superiority to a key word. The computing system is capable of operating on nine digit numbers at rates up to 240,000 operations per minute.

Up to 17 input/output devices may be connected simultaneously with the RPC-4000 system, and with minor modifications this number can be raised to 60. The computer can select automatically any one input device or one or more of the output devices up to the total number connected.

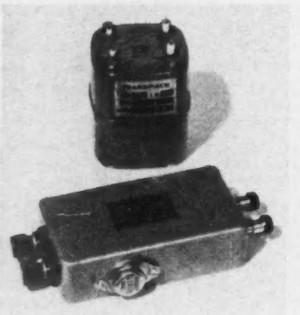
The standard input/output requirement is a tape typewriter system complete with typewriter, desk, and punch-read console all designed as one unit. Basic reader speed is 60 characters per second; basic punch speed is 30 characters per second.

Optional accessories for expanding the system include a reversible photoelectric reader which reads punch tape at 500 characters per second and a high speed punch which produces up to 300 characters per second. It is intended including a magnetic tape drum and a line printer.

The present basic system is compact later to introduce other equipment and weighs less than 1,000 lb. No site preparation or installation costs are involved. The appearance is clean to go with modern office styling. Flexibility in operation is one of the chief claims for this equipment. *Royal McBee, 36 Worship Street, London, EC2.*

CONVERTERS

Circuits based on Semiconductors



THE Transipack range of power converters use semiconductors only and have no moving parts.

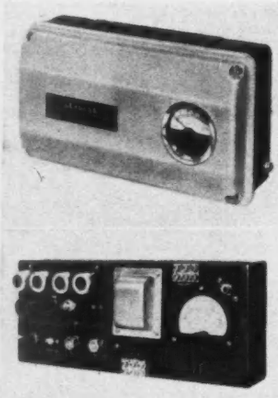
Inputs can range from 6 to 24V d.c. and outputs from 50 to 550V d.c. or up to 250V a.c. 40 to 60 cycles (square wave). Types are available either as hermetically sealed units or as open construction. Both are illustrated.

Input and output circuits are insulated from each other and both can be floating above earth. If necessary a special blocking diode can be incorporated in the input circuit to avoid damage if the polarity should accidentally be reversed. The units have very high efficiency at their full load rating—of the order of 90 per cent—and voltage regulation is also good. The circuits are protected against overload, and even complete short circuit cannot cause damage. Under constant load conditions the relationship between input and output voltages is linear.

Model 505 for an input of 12V d.c. has output voltages of 50-0-100-200-300-400-500 volts and a maximum loading of 100W. Switching frequency is approximately 1,000 c/s. In a diecast box it weighs 3 lb 15 oz. Model 707 is a smaller unit for 30W only, but with similar characteristics. No. 808 will produce 180W at 600V. Other types will handle 500 and 1,000W. The life of all the models is long—well in excess of the 500 hours specified for vibrating converters. *Transipack, 29 Burnt Ash Hill, London, SE12.*

LEVEL INDICATOR

For Solids or Liquids



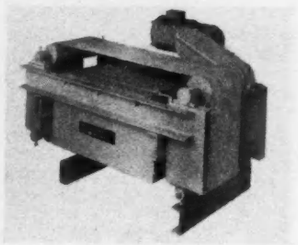
THE Levelog system has been designed for the continuous indication of the level of material stored in hoppers, bunkers or silos.

The instrument works on the capacitance principle using an electrode system fitted into the container and measuring the incremental change of capacitance as the level rises or falls. The indicating meter can be calibrated in whatever units are appropriate.

There are three main items in the equipment. The control unit houses the electronic equipment and a stabilised power pack to counteract mains variation. A calibration meter is fitted which can be seen through the cover when that is in place. The electrode system can be of the rigid variety for small vessels and of the flexible form when the depth of the container is in excess of 6 ft. The limitation of the length of the electrode is mainly a function of the material in use but can be up to 60 ft. The third item is the indicating instrument which is basically a d.c. milliameter which can be for local or remote siting according to requirements. The casing is cast iron and weatherproof. There are three ¾ in conduit entries on both top and bottom. Nearly linear scales are possible. *Thomas Industrial Automation Limited, Station Buildings, Altrincham, Cheshire.*

MAGNETIC SEPARATOR

High Intensity Field



A NEW range of electromagnetic separators operate with high intensity fields.

They are designed for the purpose of extracting feebly magnetic particles from silica sands and like materials which are travelling on existing conveyor belts, and require no alteration to customer's plant on installation.

The separators are built as self contained units in a series of sizes to cover a range of conveyors with belts from 12 in to 48 in wide. Only supporting stringers are required for installation on site.

Operation is by a cross belt principle. A framework carries a high permeability steel magnet unit with a totally enclosed high conductivity copper magnetising coil. The cross belt passing along the magnet poles immediately over the main conveyor burden extracts all the magnetic material and provides automatic discharge when the cross belt passes beyond the influence of the magnet.

A number of these separators can be installed over the same main conveyor, each unit having a different working gap and thereby enabling particles of different magnetic susceptability to be extracted in turn. Rheostatic control of the magnetic intensity can also be arranged, giving a further degree of separation.

It is claimed for these separators that they are almost maintenance free. The geared motor that supplies the power is totally enclosed and so is the chain drive. The unit is designed so that the belt can easily be changed if required. Discharge hoppers can be arranged at the delivery end of the cross belt. *Industrial Magnets Limited, 28 Station Road, Acocks Green, Birmingham 27.*

FLEXIBLE DRIVE UNIT

Variable Speed

NOW available in this country is the Nibru-Max flexible drive unit, the chief feature of which is the infinitely variable speed range.

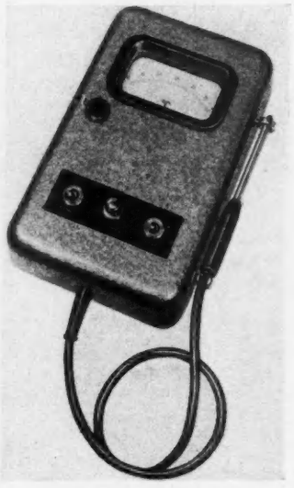
The unit is compact and easily portable from one site to another and it is claimed that savings in time up to 50 per cent are possible since the right speed for each job can be used. Finish is also improved. Power is supplied by a 2½ h.p. motor driving through the variable speed gear to two output shafts. The full speed range is from 1,000 to 40,000 r.p.m.

For light work the recommended range of speeds is from 10,000 to 40,000 r.p.m., but this is reduced for heavier work to between 1,000 and 10,000 r.p.m.

Apart from grinding operations the machine will perform all types of cleaning and polishing work with the aid of a number of attachments. Those available include cut-off wheels, discs, sanders, abrasive bands, millers, cutters, mounted points, and polishing mops. The head is mounted on a swivel so that it will turn to follow the work and there is a tray on which the tool can be rested between operations. The illustration shows a point fitted on the high speed shaft and a grinder on the slow speed fitting. *Roland Goodall Limited, Burton-on-Trent.*

SURFACE THERMOMETER

Rapid Response



A NEW electrically operated thermometer made by Hommel and now available in this country, will give accurate indication of surface temperatures within a matter of seconds.

The instrument is powered by a 3 volt dry battery of the normal torch type which is contained in the case. To measure a temperature the probe is touched on the surface and held there for a few seconds. The meter reads directly and accurately.

The instrument can be supplied with any one of four different measuring ranges: from 50° to 100° F by 0·5°; from 10° to 40° C by 0·2°; from 32° to 212° F by 1° and from 0° to 100° C by 0·s°. Calibration of the instrument is said to be simple. A shoulder strap and carrying case can be supplied.

A suggested use for the thermometer is the checking of slip gauges to see that they are at the same temperature as the component. The long time that had to be allowed (at least an hour) to ensure that the same temperature was attained can often be greatly reduced. *Rubert and Company Limited, Acru Works, Councillor Lane, Cheadle, Cheshire.*

SOIL COMPACTER

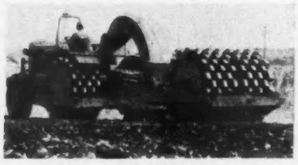
Fast Travel

A FAST travelling compacter has been introduced for all classes of soil and rock fill.

The DW20A offers economy in soil compaction owing to its high speed facility. High production compaction can be obtained at running speeds up to 15 m.p.h. This has made possible consistent production rates up to 1,200 cu. yards per hour. The unit is available with either interchangeable tamping wheels of new design or with existing " Grid " wheels.

The DW20A compacter operates as an integral part of the Caterpillar DW20 tractor. The rear tractor wheels are replaced with compacting wheels and a gooseneck trailing roller contains two similar wheels. The coverage width of the combination set-up is 10 ft. The existing tractor axles, brakes, and bearings are used unchanged for the compaction wheels.

The new tamping compacter utilises wheels designed to work at high speeds and achieve almost complete " walkout."



The design is best suited for plastic type soils. A sloped pad tamping foot enables the drive wheels to develop more tractive effort than flat pads. Higher gradability can be obtained with traction aiding devices.

The " Grid " compacter is basically the same unit but is equipped with open surface grid wheels of heat treated cast alloy steel construction. Also a high speed unit, it is best for gravelly soil and rock crushing.

A variety of ballast combinations may be applied to either compacter to suit the work in hand. The recommended ballast is three 4,000 lb steel weights carried on the frame of the towed unit. Steel ballast of 5,000 lb is suggested for the tractor. In addition wet sand may be carried in the compaction wheels *Hyster Company, 2902 N.E. Clackamas Street, Portland, 8, Oregon, USA.*

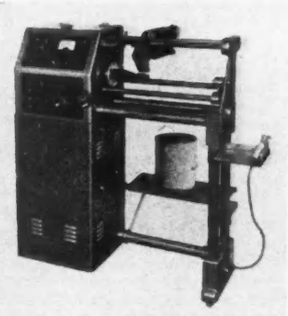
COIL WINDER

Layers Without Interleaves

THE Supermatic coil winder is said to be able to produce almost perfect layer wound coils without the use of any interleaving material.

The headstock mandrel of the machine is not mechanically coupled to the traversing carriage in any way. The traverse mechanism is driven by a separate electric motor and its speed is electronically controlled so that the wire is always fed to the coil from the correct position with a predetermined angle of lag. If self bonding wire is used it is possible to obtain products with a very high space factor.

The machine will handle round, square, or rectangular coils from 0·1 in to 8·5 in in length and up to 4·5 in in diameter. Coils can be wound on collapsible mandrels or on formers or bobbins. Wires from 47 s.w.g. to 18 s.w.g. can be handled. There are three changes of gear to adjust the ratio of traverse speed to headstock speed. The control that determines the angle of lag can be set to suit the gauge



of wire being used; it can also be set to give accurate single layer space coils.

The recommended winding speed is 1,200 r.p.m. but the maximum is 3,000 r.p.m. The speed is controlled by a variable transformer mounted on the control panel. A five-figure lever reset counter is included and this will also stop the machine when the set number of turns has been wound. *Avo Limited, Avocet House, 92-95 Vauxhall Bridge Road, London, SW1.*

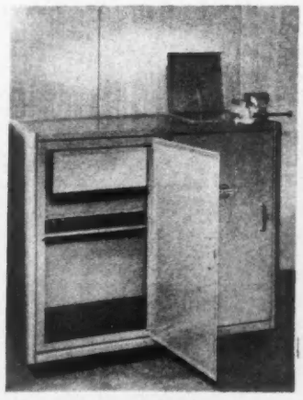
MOBILE WORK BENCH

For Light Duty

LIGHT-duty benches in a new range are made in steel and mounted on castors for moving about.

The series B contains three standard sizes known as models 2, 3, and 4, which are 2 ft, 3 ft, and 4 ft wide, respectively. Model 3 is illustrated. Basically, the bench is a folded steel structure made to the standard height of 2 ft 8 in, and 20 in deep. The working surface is a flat steel top with a slightly raised lip all round to prevent tools rolling off. There is storage space in the interior which is fitted with a drawer and a flanged removable shelf running the whole length of the bench. The model 2 has a single door; the others have two. All are fitted with a padlock and hasp. All are fitted with ball bearing castors and steadying sprags as standard items.

Optional extras that can be provided include a 3 in vice and a vertical rack that will take up to four drawers in place of the single drawer normally fitted. In addition, the two larger sizes can be



equipped with a removable paraffin cleaning bath, complete with sludge trap, mounted in the working surface. The benches are supplied as a kit of parts ready for assembly, using only a screwdriver and spanner. *Mann Egerton and Company Limited, 5 Prince of Wales Road, Norwich.*

DIESEL DUMPER

Articulated Chassis

POWER for a new ¾ yd diesel dumper is supplied by a Petter AVAIT air cooled engine.

The dumper, model 1/20, has a patented articulated chassis that enables it to give good performance in cross country operation. Positive rear wheel drive gives good traction and Ackerman front wheel steering coupled with high ground clearance aid in this ability.

It has a three speed drive and reverse synchro mesh gearbox which transmits to the axle by the " Power Grip " drive that is claimed to be positive and slip free even when used in conditions of very short centres.

The drive is totally enclosed in a dust proof casing and is said to have long life and not to require adjustment or lubrication. The steering gear is made entirely of heat treated alloy steel drop forgings and the steering box is the worm and peg type. Steering is said to be positive and light.

The skip has a low loading height and is made of $\frac{5}{16}$ in steel plate. It has a

self tipping and return action. The short wheel base and the good steering lock combine to give good manoeuverability; the inner turning radius is 4 ft 3 in and the outer 9 ft 9 in.

The dumper can easily be converted to take the Trip Skip units enabling it to be used for automatic multiple skip handling. The equivalent load is 1 ton and it is stated that the skip cannot be overloaded to cause damage. The dumper is designed for long life and trouble free service with a minimum of maintenance. *C. H. Johnson (Machinery) Limited, Adswood, Stockport, Cheshire.*

VIBRATION METER

Transistorised

THE type 1431 vibration meter is a compact portable instrument covering the frequency range from 10 c/s to 1,000 c/s.

Power is supplied by eight torch batteries which will operate the instrument for about 80 hours as the consumption is only 2W.

Vibration is sensed by a moving coil pick-up which has a natural frequency of 5 c/s, well outside the instrument range. The signal is amplified and fed through the adjustable attenuators to give the nine scale ranges. The metering circuit is designed to give stability and linearity. Calibration is maintained by negative feedback and the use of a Zener diode circuit in the supply.

If desired, integration and differentiation networks can be switched into circuit to give direct readings of displacement and acceleration. An output jack gives a connection to an oscilloscope or to a frequency analyser. The vibration range of the pickup covers a maximum amplitude between stops of

approximately 0·6 in and a maximum acceleration of 10,000 in per sec², or just under 26*g*. Sensitivity is sufficient to give full scale deflection for a displacement of 0·0003 in (peak to peak), and readings can be made directly to 0·000005 in. *Dawe Instruments Limited, 99 Uxbridge Road, London, W5.*

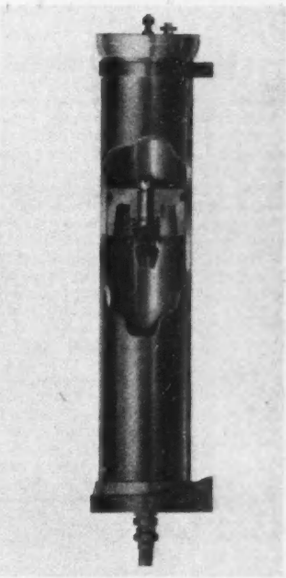
HYDRAULIC ACCUMULATORS

5,000 lb per sq. in

THREE new series of hydraulic accumulators are now available for pressures up to 5,000 lb per sq. in and capacities up to 20 gallons.

The units all incorporate the patented " liquid seal " designed to overcome the difficulty of sealing the gas charge during shut down periods. A probe is used to close the oil outlet of the accumulator when it is discharged and utilises the pressure difference arising from the difference in areas to complete the seal.

Series I covers the pressure range up to 2,000 lb per sq. in and has models with capacities ranging up to 8 gallons; series II is also for 2,000 lb per sq. in but covers capacities from 8 to 20 gallons. Series III and IV are for pressures of 5,000 lb per sq. in and capacities from 1 to 8 and from 8 to 20 gallons, respectively. All models have screwed end construction and incorporate interlocks to prevent their being dismantled while under internal pressure. *Industrial Hydraulics Limited, 101 London Road, Reading, Berkshire.*



Electrical Engineers Exhibition

THE ninth Electrical Engineers Exhibition, which closed at Olympia on 9 April, recorded attendance figures well in excess of 75,000. This is an increase of over 10 per cent on last year and included 889 oversea visitors from 74 countries. The number of exhibitors was also higher.

The encouraging number from overseas is no doubt due to the publicity that was given beforehand, particularly in the European Free Trade area. Electrical goods are one of the basic items of export and a single order for domestic equipment to the value of $1 million, taken on the first day, was certainly a good start. Some items on show were described in our issue of 1 April and more are given here.

RELAY

Operating on 15 Microamperes

DEVELOPED for switching power where only a very small signal is available is a new transistorised relay.

The device has three stages with silicon transistors working on a power supply of 12V d.c. 30 mA. A current of 15μ A applied to the control circuit will cause it to operate. Operation is unaffected by temperatures up to 65° C ambient.

Printed circuits are used in the construction and the overall dimensions of the complete unit, including the relay itself, are only 2 in by 1¼ in by 1¼ in. The relay plugs into the amplifier. The contacts and connectors are gold plated to minimise overall resistance and the printed circuit fits into a standard polarised 18-way socket. *B and R Relays Limited, Temple Fields, Harlow, Essex.*

PEAK ACCELEROMETER

Shock Testing

A PEAK accelerometer for use in shock tests has recently been developed. It can also be used for vibration work.

A small but robust probe unit is fitted to the sample under test. It consists of a barium titanate crystal accelerometer fitted in a metal housing with an output lead of screened coaxial cable 15 ft long for connecting to the indicator. The latter incorporates a cathode follower and a.c. amplifier, a low pass filter with a cut-off frequency of 675 c.p.s., a peak reading indicator, and an output socket for displaying the acceleration pulse on a cathode ray oscilloscope.

The mirror scale indicator has two scales and four ranges covering accelerations from zero to 1,000g. The minimum readable value is 3g. When set for shock testing the reading remains for a period of 15 seconds, but if set for vibration testing the reading fluctuates with the amplitude. A "standby-operate" switch can be used to return the pointer to zero after a reading. The frequency response is linear within 2 per cent over the range from 7·5 c/s to 1·25 kc/s with the filter out, and from 7·5 c/s to 275 c/s with the filter in. The oscilloscope output impedance is less than 5,000 ohms and the voltage is approximately 18 at the full-scale deflection of the indicator. Input loading is 20 watts and the instrument is normally supplied for 230-250 volts operation at 50 cycles. Alternatively, it can be supplied for 105-120V, 50 to 70 cycles.

The probe alone weighs 0·96 oz and the cable 5·39 oz. The indicator unit measures 13¼ in by 10½ in by 6½ in and weighs 15¾ lb. *Ferranti Limited, Hollinwood, Lancashire.*

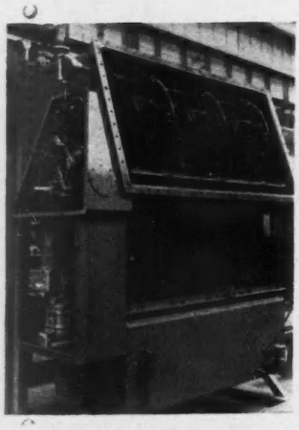
HIGH TENSION TAP CHANGER

Maintenance Free

IT is claimed for a new high tension tap changer that it will not require maintenance until after at least 200,000 operations or approximately its whole life of 25 years.

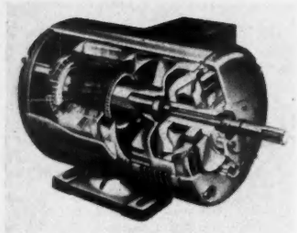
The unit is of the resistor type designed for use on systems up to 500 kV. Current ratings are up to 1,000 A. It has been made to comply with BEBS T2(1958) and to continental test standards. Satisfactory operation of the selector and divertor switches has been obtained over the temperature range from +90° C to − 20° C and the selector switch has been subjected to 6 million operations without failure.

The operation is high speed, the current being broken within the half cycle, that is in 0·06 sec. The final movement is by a charged spring so that failure of the driving motor cannot stop the action once initiated. The divertor switch contacts have a pure rolling contact, make and break occurring on special arcing tips. Vacuum moulded epoxy resin supports are used for both the selector and divertor switches, designed to give a very long creep path. The whole assembly is immersed in oil to just below the crankshaft that operates the divertor switches. For this Tufnol bearings are used requiring no lubrication. *English Electric Company Limited, Transformer Department, Stafford.*



VARIABLE SPEED UNIT

Close Control



A COMBINED motor coupling unit has been introduced which is capable of giving infinitely variable speeds over a 10 to 1 range.

The "Adjusto-Speed" consists of a squirrel cage motor (of up to 2 h.p.) driving an air-cooled eddy current coupling mounted in a common housing. In a separate box is the control adjustment. Alternatively, low voltage controls can be used for automatic tensioning, acceleration control, or synchronisation.

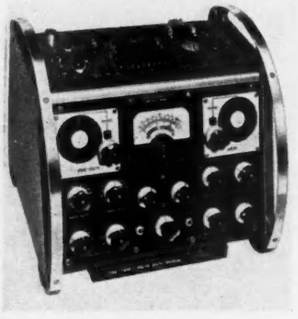
The motor and input member of the coupling run at constant speed while the output member runs under control of the coupling field. There is no mechanical connection. A small tachogenerator is built into the housing and the variable speed shaft extends through the unit so that power is available at either end.

The speed of the driven shaft is controlled by the amount of direct current fed from the rectifier unit to the coupling field coil. The control unit has a grid controlled thyratron valve for both the rectification and speed control. The stable feedback system obtains its reference from the tachogenerator.

The circuit is designed to give close speed control over wide changes in load. An accuracy of ±15 r.p.m. can be expected. At 1,200 r.p.m. this is less than 1·5 per cent. The dimensions of the drive unit are 15½ in overall length; housing diameter 6½ in; centre height 3½ in and shaft diameter ⅝ in. The control unit measures 5 in by 6½ in high by 4 11/16 in deep. Response time is very rapid for speed increases but depends on the loading for decreases; a brake can be fitted to give a quick stop. *Heenan and Froude Limited, Worcester.*

VALVE TESTER

Low Negative Grid Potential



THE Mark 4 valve characteristic meter is an improved version of earlier models.

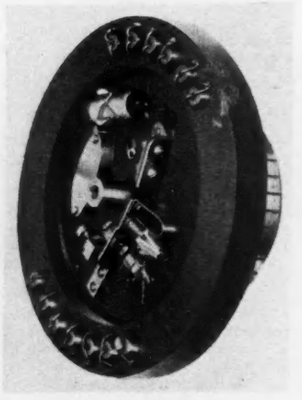
The instrument offers increased facilities for setting negative grid potentials, particularly at low values, and incorporates more accurate and precise methods for determining the grid current when the valve suffers from reverse or primary emission. An additional anode voltage has been included for testing the newer types of low anode voltage valves, and the regulation of the screen and anode voltage supplies has been improved to reduce reflected impedance problems. An overload protection is fitted to safeguard the movements.

Anode voltages range from 12·6 V to 400 V in steps, and the screen voltages from 12·6 to 300 V also in steps; the grid voltage is continuously variable from 0 to 100 V. Anode currents are from 2·5 mA (full scale deflection on the meter) to 100 mA, and screen currents are over the same range. The grid current can be between 0 and 100 μA. Filament heater voltages can be set from 0·625 to 117 V covering most valve requirements. Mutual conductance values are from 0·1 to 60 mA per volt.

The instrument can be fitted with "go-no go" facilities for selective testing, and diodes and rectifiers can be tested under reservoir load conditions anywhere over the range from 1 mA to 180 mA. A comprehensive range of bases is fitted. *Avo Limited, 92-96 Vauxhall Bridge Road, London, SW1.*

CENTRIFUGAL GOVERNOR

D.c. Motors



A NEW centrifugal governor for direct current motors will give speed control to within 0·5 per cent.

The illustration shows the governor with the cover removed. There is only one moving part, a single leaf spring which makes and breaks the contact points. A series of resistance units is arranged around the periphery of the governor, which are connected or disconnected from the shunt field of the motor. Across the contact points (which are of a rare metal to give long life) is a capacitor to quench sparking; a nut adjusts the setting of the spring to suit the motor speed required.

There are two models made. The first is for motors operating from supplies of 24 to 50V and will maintain the set speed to within 0·5 per cent; the second is for motors in the 50 to 220V range and has regulation of ± 0·75 per cent. In both cases mains variations of up to 12½ per cent and a 7½ per cent inherent full load to no load regulation can be accommodated. Normal motor speed range is from 1,500 to 300 r.p.m. and the field dissipation can be up to 100 W.

It is claimed that no adjustment is required over periods from 1,500 to 3,000 hours according to usage, and drift is almost eliminated. *Electro Dynamic Construction Company Limited, St. Mary Cray, Orpington, Kent.*

The Tentative Plasma

WHAT was once called a fusion machine became a " thermonuclear device " following the disappointment with ZETA, OGRA, and Perhapsatron two years ago. Now the fashionable name is " plasma experiment " for similar devices, showing how much the scientist's gunsights have been lowered in the intervening period. Work nevertheless continues, and a new machine for the study of plasma instabilities has just been commissioned at Harwell.

Stability Studies with Spider

Spider is a fast toroidal pinch experiment designed to show that it is possible to set up an approximation to the simple stabilised pinch in the confinement geometry of a torus. The main component of the machine is a quartz torus of 10 cm bore and 64 cm diameter shown in Fig. 1. The gas contained by the torus forms the secondary coil of an air-core transformer. The primary windings of the transformer consist of a close fitting copper shell round the torus. The shell is divided into four quadrants around the major circumference. Each quadrant is connected to a bank of capacitors rated 10 microfarads at 30 kV. The capacitors are discharged in series through coaxial cables by the breakdown of 40 spark gaps. The resulting current rise is 10^5 amperes in $1{\cdot}5 \times 10^{-6}$ seconds, with a voltage of 70 kV around the torus. Prior to the fast discharge the gas contained in the torus is preheated and ionised. So far the experiments have shown that when the skin current collapses, a cylindrically imploding hydromagnetic shock is produced. Further work will concentrate on pinch stability and shock heating studies.

Duoplasmatron Ion Source for DCX Injector

A new high-intensity ion source is under development for the DCX thermonuclear device of the Oak Ridge National Laboratory (Atomic Review, 18 July, 8, 22, 29 Aug. '58). The injector will produce over 25 milliamperes of mass-analysed singly-ionised molecular hydrogen, accelerated to 600 keV. Similar ion sources have been under development at the laboratories of Goodrich-High Voltage Astronautics Inc., a subsidiary of B.F. Goodrich Company and High Voltage Engineering. The aim of the initial development was to provide an extension to 12 MeV tandem Van de Graaff accelerators, and ion propulsion devices for space satellites. The new ion source is a further development of the duoplasmatron ion source used by High Voltage in high-current accelerators.

Existence of Positive Anti-Sigma Hyperon Confirmed

Examination of 40,000 photographic plates obtained from the propane bubble chamber of the Dubna research institute revealed tracks which confirm the existence of positively charged anti-sigma-hyperons. Existence of anti-hyperons has long been postulated, but experimental verification was lacking for the charged varieties: the negative and positive anti-sigma-hyperons. The particle that left the important tracks on the Dubna plates has a positive charge, mass of some 2,328 electron units, and grows to the ripe age of 1×10^{-10} sec before disintegrating into an anti-neutron and a positive π-meson. The Dubna high-energy institute is under the leadership of Professors Vladimir Wechsler and Wang Kang-chang, and operates a 10 GeV proton synchrotron, called a synchro-phasatron by the Russians.

Notes and News

Steam Generator as Second String to AGR

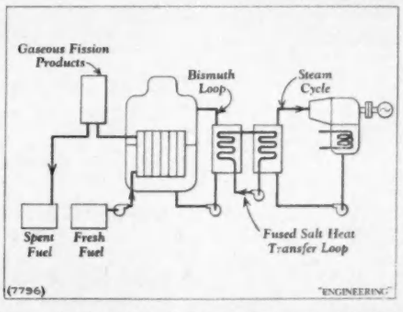
A steam-generating heavy-water moderated reactor (SGHWR) is believed to be under consideration as a second string to the Advanced Gas-cooled Reactor now being built at Windscale by the UKAEA. Unlike the steam-cooled heavy-water moderated reactor, the SGHWR will permit boiling of the light water in the reactor core. As in the steam-cooled system, the heavy water will be contained in pressure tubes. Presumably, in spite of the additional structural material required, the neutron economy of using heavy water as moderator gives a reasonable advantage over the straight boiling-water system—at least where highly enriched uranium is scarce. The Industrial Group of the Authority are expected to allocate development contracts relating to the new system to various private companies. Work on the AGR is understood to have been complicated by difficulties in connection with the graphite moderator, which needs to be sheathed at the high gas temperatures envisaged, and with the beryllium fuel canning. (See Atomic Review 9 Oct. '59 and 12 Feb. '60). It may be significant that one company with extensive facilities for the development of beryllium has adopted stainless steel as the canning material for its own advanced gas-cooled reactors.

Origin of UKAEA Heavy-Water Project

The Atomic Energy Authority's interest in steam-cooled heavy-water moderated reactors was first revealed in characteristic UKAEA fashion: abroad, in a speech by Sir John Cockcroft. At a symposium held in conjunction with the Milan Trade Fair, Sir John said: " We are actively interested in the development of a heavy-water steam or gas-cooled reactor, since this is a reactor which has many potential advantages and seems likely to achieve high efficiencies, low capital costs and low fuel costs." In spite of the prospects, the steam-cooled heavy-water proposal of Vickers Nuclear Engineering Limited, submitted last year to the Galbraith Committee on nuclear ship propulsion, was rejected in favour of the boiling-water and organic-liquid moderated reactors. Nevertheless, interest has now been revived, and the concept was resubmitted for land-based applications in ENGINEERING's survey of small power reactors (ENGNG., 15 April '60, p. 517).

Fig. 1 (right) Adjusting the spectrometer of the fast toroidal pinch experiment " Spider " at Harwell.

Fig. 2 (below) Schematic arrangement of an internally cooled liquid-metal fuelled reactor.



Canned Liquid Metal Fuel Reactor

Although still in the experimental stage, the internally cooled liquid-metal fuelled reactor using separate fuel and coolant circuits has the advantage of continuous fission-product removal and low operating pressure. Essentially the system consists of the four fluid loops shown in Fig. 2: the fuel loop, the primary coolant loop, the secondary coolant loop, and the steam cycle. The fuel is uranium 235 or plutonium dissolved in a suitable metallic carrier such as bismuth, and is pumped into a series of " fuel elements " forming the core. The elements consist of an assembly of graphite sleeves, which serve as moderator, sheathed in a metallic can. Bismuth coolant is circulated through the interspaces between the fuel-moderator tubes, and is maintained at a slight overpressure to prevent large-scale escape of fission products should one of the elements rupture. The coolant pressure is only 75 lb per sq. in. Owing to the induced alpha-activity of bismuth, an intermediate heat-transfer loop, operating on low-pressure fused salts, has to be interposed between the primary coolant and the steam cycle. The turbines receive 900 lb per sq. in steam at 871° F, resulting in an overall gross thermal efficiency better than 30 per cent. Apart from the complication of four independent fluid loops, the chief problems associated with the concept arise from the solubility of steel in bismuth, the high alpha-activity of the primary coolant, and the uncertainties of graphite as a structural material. The graphite-bismuth system has a high negative temperature coefficient of reactivity, and the possibility of continuous fission product removal and fuel replacement should make the concept highly attractive for small reactors or ship propulsion once the associated problems have been solved. (A. N. Byford, "A Possible Nuclear Reactor System for the Propulsion of Smaller Ships," lecture to the Graduates' Section of the Institution of Mechanical Engineers.)

Survey of Pressure-Vessel Design Practice

An excellent survey of reactor pressure-vessel design practice has been published (in French) by Bureau Vertias, the international shipping and aircraft registry, dealing with every aspect of pressure-vessel loading for gas-cooled, water cooled and moderated, and organic-liquid cooled and moderated reactors. A comprehensive table of contents and a well-organised bibliography containing 56 entries makes the work an excellent source of references for pressure-vessel designers. The treatment extends to thermal cycling and shock, dynamic pressure increases due to the acceleration of ships, dynamic loading on internal fixtures due to the acceleration of coolant inside the vessel, fatigue conditions and reactor power excursions. Of particular interest to designers of ship reactors are the proposed differential equations describing the motion of ships with six degrees of freedom, and the experiments performed on the vertical accelerations of the Ginga-Maru and Hokuto-Maru. (R. Mattera: " Les Cuves de Reacteurs," *Bulletin Technique du Veritas*, vol. 42, No. 3, March, 1960.)

Plutonium Core for Dounreay?

Indications are that the Dounreay fast-breeder reactor will soon begin to operate on some plutonium fuel. The UKAEA have announced that with the completion of the first series of experiments the reactor will now be shut down for a three-months period during which changes will be made in the core. The changes are aimed to permit " a wider variety of types of fuel " to be tested, according to the UKAEA press release. The change would indicate that some plutonium fuel will now be used. The original loading with which the reactor was first brought to criticality on 14 November last year contained uranium 235, although the project's aim is to develop a reactor that will operate on plutonium.

From Absorber to Zeta: A Glossary of Terms

A useful little booklet, designed to fit into the pocket, has been prepared by the UKAEA public relations branch. The book contains a glossary of terms in current use from " absorber " to " Zeta," each explained in simple language. Entries include technical terms technical slang (hard-gammas, hex.) and the names of better known reactors, with explanations. One entry will puzzle the uninitiated: according to the book " BeV is American for GeV." But a full explanation is given under letter G. (*Glossary of Atomic Terms*, HMSO, 3*s* 6*d*.)

World Reactor Companies, Associations and Activities

CONTINUING ENGINEERING's chart of British reactor groups, which appeared in the pink supplement of the 15th April issue, the following is a similar survey extended to cover the world. The survey will be completed in several issues of ENGINEERING.

Austria

Austro-Chematom

Linz. — Fuel fabrication and heavy water production for Euratom countries.

International consortium comprising Oesterreichische Stickstoffwerke AG, Degussa, Germany, and Rio Tinto Mines, London.

Belgium

Atelier de Constructions Electrique de Charleroi (ACEC)

Charleroi, Belgium. — Power plant component manufacture.

Associated with Westinghouse Electric Corporation and Cockerill-Ougrée.

Belgonucleaire

35 Rue des Colonies, Brussels. — Design of reactor BR-3.

Consortium of nearly 50 companies, associated with Nuclear Development Corporation of America.

Canada

Atomic Energy of Canada Ltd.

PO Box 711, Ottawa, Ontario. — Development of natural uranium heavy-water moderated research and power reactors. Own and operate reactors Zeep, NRX, NRU, and PTR, and under construction is Zed-2. Designed the Canada-India reactor; construct with Ontario Hydro and Canadian General Electric the 20 MW(e) power demonstration plant NPD-2, and the full-scale power plant Candu. Study organic-liquid cooled heavy-water moderated natural uranium reactors with Canadian General Electric Co.; and small enriched uranium reactors with Canadian Westinghouse Co. Commercial products division supply radioactive isotopes and equipment for their use in industry and medicine.

Crown company responsible for the implementation of Canada's atomic energy programme. Three divisions are Reactor Research and Development (Chalk River), Nuclear Power Plant (Toronto), and Commercial Products (Ottawa).

Canadair Ltd.

PO BOX 6087, Montreal. — Designed and constructed the zero-power pool test reactor for Chalk River and a sub-critical facility for the University of Toronto. Nuclear activities were terminated in 1959, with some of the staff transferring to General Atomics.

Division of General Dynamics Corporation.

Canadian General Electric Company Ltd.

214 King Street West, Toronto. — Prime contractors for NPD-2, received research and development contract for organic-liquid cooled heavy-water moderated reactors.

Associated with General Electric (US).

Canadian Westinghouse Company Ltd.

286 Sanford Avenue North, Hamilton, Ontario. — Research and development of nuclear fuels and fuel elements, received study contract to evaluate light-water reactors for small power stations.

Associated with Westinghouse Corporation.

C. D. Howe Company Ltd.

Montreal, P.Q. — Engineering design of research reactor NRU in collaboration with Atomic Energy of Canada Limited.

Foster Wheeler Ltd.

St. Catharines, Ontario. — Detail engineering design and construction of the zero-power test-reactor ZED-2 for Atomic Energy of Canada Limited.

Winnett Boyd Associates

745 Mount Pleasant Road, Toronto, and 720 Marin Avenue, Montreal. — Design and development of high-temperature gas-cooled reactors.

Patent agreement with Arthur D. Little Inc. of Cambridge, Massachusetts.

Denmark

Danatom

Strandvejen 102, Hellerup, Copenhagen. — Power and propulsion reactor studies. Completed ship propulsion study Alpha, and gas-cooled graphite-moderated power reactor study Beta.

Consortium of large electrical, mechanical and shipbuilding firms.

France

Association Technique pour la Production et Utilisation de l'Energie Nucleaire (ATEN)

4 Rue de Teheran, Paris 8. — Promotion of nuclear power in France.

Association sponsored by the Commisariat de l'Energie Atomique and Électricité de France, comprising eighty companies.

Auxi-Atome

11 Rue de la Pepiniere, Paris 8. — Nuclear power plant auxiliaries.

Consortium of twelve chemical, metallurgical, electrical and electronics manufacturers.

Caratom (Compagnie d'Applications de Recherches Atomiques)

45 Ave. Kleber, Paris 16. — Design of reactor plants and auxiliaries.

Consortium formed by Compagnie Hispano-Suiza, Breguet, and others.

CERCA (Société pour l'Etude et la Ralisation de Combustibles Atomiques)

16 route de Staines. Bonneuil sur Marne (Seine). — Research and manufacture of fuel elements.

Chantiers de l'Atlantique (Penhoet-Loire)

7 Rue Auber, Paris 9. — Heavy mechanical engineering.

Member of Framatome, Dynatom, Groupment Atomique Alsacienne et Atlantique, and Groupe Loire-Penhoet.

Dynatom

C/o Société Alsacienne de Constructions Mechaniques, 69 rue de Monceau, Paris 8. — Power station and marine construction based on Atomics International reactor design.

International consortium comprising Atomics International, Societe Alsacienne de Constructions Mecaniques, and Chantiers de l'Atlantique (Penhoet-Loire).

Forges et Ateliers du Creusot

15 Rue Pasquier, Paris 8. — Heavy engineering, nuclear fuels.

Member of Framatome and joint owner with Service Nucleaire St. Gobain of Centre de Recherches pour Combustibles Atomiques.

Framatome (France-Atome)

6-8 Blvd. Haussmann. — Construction of reactors G1, G2, G3, and EL3.

Consortium comprising 22 companies which include Société Alsacienne de Constructions Mecaniques (SACM), Société General de Constructions Electriques et Mecaniques Alsthom, Societe des Forges et Ateliers du Creusot (SFAC), Societe des Forges et Ateliers de Constructions Electriques et Mecaniques Jeumont, Air Liquide, Société Rateau, Compagnie Française Thompson-Houston (CFTH), Société des Chantiers Réunis Loire-Normandie, Chantiers de l'Atlantique (Penhoet-Loire), Société de Fives-Lille, Société d'Ugine, and Société "Le Materiel Electrique SW." Associated with Westinghouse Corporation.

Groupe Loire-Penhoet

C/o Chantiers de l'Atlantique (Penhoet-Loire), 7 Rue Auber, Paris 9. — Heavy mechanical engineering. Construction of reactors G2 and G3.

Association of Chantiers de l'Atlantique (Penhoet-Loire) and Société des Chantiers Réunis Loire-Normandie.

Groupment Atomique Alsacienne et Atlantique (GAAA or G3A)

100 Av. Eduard Herriot, Le Plessis-Robinson (Seine). — Power station and marine construction.

Association of Société Alsacienne de Constructions Mecaniques et Electriques, and Chantiers de l'Atlantique (Penhoet-Loire).

Indatom

48 Rue la Boétie, Paris 8. — Design and construction of complete reactor stations. Prime contractors for the reactors Melusine, Triton, Minerve, design studies of nuclear ships, boiling-water reactor stations.

Consortium comprising Compagnie des Ateliers et Forges de la Loire, Société Française des Constructions Babcock et Wilcox, Compagnie Electro-Mecanique, Compagnie des Forges de Chatillon, Commentry et Neuves-Maisons, Etablissements Neyrpic, Société Pechiney, Société St. Gobain, and Campagnie General de Telegraphie sans Fil, and two banks. Associated with the Babcock and Wilcox Company Ltd. (US).

SATNUC (Société pour les applications techniques dans le domaine de l'energie nucleaire)

45 Boulevard de la Gare, Paris 13. — Plutonium extraction plant; reactor equipment; electronic equipment; treatment of effluents; turbo-ventilators, motors, sluices, valves; filtration equipment; pressure vessels; heat exchangers; land and marine reactors; telemanipulation equipment; hot laboratory equipment.

Membership includes: Ateliers Repatel et Mulatier, Baudot-Hardoll, Carbonisation et Charbons Actifs, Delattre et Frouard Réunis (Ets), Compagnie Française d'Entreprises, Merlin-Gerin (Ets), Société de Produits Chimiques et Engrais d'Auby, Steain et Roubaix.

SCUMRA (Société Centrale de l'Uranium et les Minerais et Métaux Radioactifs)

33 rue de la Boétie, Paris 8. — Prospecting; manufacture of radiation counters.

To be continued

'Engineering' Appointments Section

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

LITTLEBROOK POWER STATION

Ref.: ENG/140

PHYSICIST and MECHANICAL ENGINEERS required in the Applications Laboratory at Littlebrook Power Station, **DARTFORD, KENT.**

The successful candidates will join a team working on the development of an advanced steam cycle for power generation employing high temperature steam as the working fluid for a "gas turbine" as proposed by J. F. Field (*Proceedings*, I.Mech.E., vol. 162, p. 209, 1950 refer). This cycle could conceivably be operated with coal, oil or nuclear fuel, and provides an opportunity to gain experience in many aspects of power generation.

An experimental 1,400 deg. F. steam superheater with a capacity of 100 k.lb./hr. is already in operation and design study on a complete pilot plant has commenced.

(*a*) THE PHYSICIST should preferably have an honours degree and some experience in research work would be an advantage. The work in which he will be engaged would be mainly radiant and convective heat transfer, aerodynamics, and measurements connected with combustion problems.

(*b*) The MECHANICAL ENGINEERS should preferably hold an honours degree and have some experience in Mechanical Engineering, and will be required to study problems involving one or more of the following:—

The thermodynamics and aerodynamics of steam and gas turbines, and axial flow compressors. Steam cycle analysis. Radiant and convective heat transfer. High temperature metallurgy. General mechanical design.

Final year students who are interested in this project are invited to apply, with a view to joining the team on completion of their studies.

Salaries will be on a scale within a range rising to £1350 p.a., according to duties and responsibilities.

Applications concerning these appointments, which afford every prospect of advancement, should be made to the PERSONNEL OFFICER, 24/30, HOLBORN, LONDON, E.C.1, stating age, qualifications, experience, present position and salary, as soon as possible. Envelopes should be marked "Confidential," together with the reference of the post in which you are interested. B 827

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS

AND

EXHIBITION BURSARY

Applications for the above Bursary are invited from graduate engineers or those holding equivalent professional qualification in civil or municipal engineering, and with professional experience.

The Bursary, value £750 and tenable for one year, has been established at the College by the Council of the Public Works and Municipal Services Congress and Exhibition, to enable suitable persons to undertake postgraduate studies or research in Public Health Engineering or Highway Engineering.

Application forms for return by 1st June, 1960, and further details may be obtained from the PROFESSOR OF CIVIL ENGINEERING. B 818

MECHANICAL ENGINEER

required in established Development Department handling design and installation of a wide variety of plant for carbon black manufacture. Experience of this particular industry not required.

This appointment will be attractive to engineers seeking opportunities to accept responsibility and obtain advancement with a young and expanding Company.

Applicants should have a sound basic practical and theoretical training and be capable of taking part in a wide variety of plant and engineering projects, and should hold an engineering degree or equivalent qualifications.

5-DAY WEEK.

STARTING SALARY IN RANGE OF £1100 TO £1200 P.A.

Apply stating age, experience and qualifications to:

PHILBLACK LIMITED

SEVERN ROAD, AVONMOUTH, BRISTOL.

for the attention of the WORKS MANAGER. B 857

PUBLIC APPOINTMENTS

MIDDLESEX COUNTY COUNCIL

(1) SENIOR ENGINEER, APT. IV (£1065-£1220) for design of heating and hot and cold water services.

(2) ENGINEERING INSPECTOR, APT. II (£765-£880) for supervision, etc., of installation of heating services, etc.

Both posts: established, pensionable. London Weighting payable up to £30.

Application forms from COUNTY ARCHITECT (s.a.e.), 1 QUEEN ANNE'S GATE BUILDINGS, DARTMOUTH STREET, S.W.1, returnable by 2nd May. Prescribed conditions. (Quote C.336E) B 819

SOUTH OF SCOTLAND ELECTRICITY BOARD

Applications are invited for a superannuable appointment as a HEATING AND VENTILATING ENGINEER in the Development Section of the Chief Commercial Officer's Department at Board Headquarters.

Duties will comprise the design of space heating and ventilation schemes including hot water central heating using electrode boilers and similar equipment.

Candidates should have a sound technical training in heating and ventilation. Experience in the preparation of estimates, specifications and drawings for central heating plants is required. Qualifications leading to membership of the Institution of Heating and Ventilation Engineers are desirable.

Salary, N.J.B., Class AX/EX, Grade 5—£1090/£1355 per annum.

Apply, quoting reference number C2/60, on the standard form available from the SECRETARY, SOUTH OF SCOTLAND ELECTRICITY BOARD, INVERLAIR AVENUE, GLASGOW, S.4, not later than 29th April, 1960. B 820

UNIVERSITY OF MALAYA IN KUALA LUMPUR

LECTURESHIPS OR ASSISTANT LECTURESHIPS IN ENGINEERING

Applications are invited for appointment to LECTURESHIPS or ASSISTANT LECTURESHIPS IN ENGINEERING, depending on the qualifications and experience of the successful candidates. The appointees will be expected to assume duty as early as possible. Special attention will be given in considering one of the appointments to candidates competent to conduct courses in Metallurgy to degree level. Candidates must be University graduates in Engineering and hold recognised professional qualifications.

The salary scale for a Lecturer is £1148 by £49 to £1442/£1540 by £56 to £1820 and for an Assistant Lecturer £1001 by £49 to £1099. In addition a variable allowance is at present paid at 35 per cent of basic salary, subject to certain maxima, together with expatriation allowance at specified rates.

First class sea passages are provided for the appointee and his family; a furnished house of flat is also provided at a reasonable rental.

Further particulars and information as to the method of application may be obtained from the SECRETARY, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36 GORDON SQUARE, LONDON, W.C.1.

Applications close, in Malaya and London, on 30th MAY, 1960. B 844

BUCKINGHAMSHIRE EDUCATION COMMITTEE

WOLVERTON COLLEGE OF FURTHER EDUCATION

(Principal: K. W. B. SHARP, B.Sc.)

Required from 1st September, 1960, LECTURER to teach PRODUCTION ENGINEERING subjects to the requirements of Higher National Certificate and Final City and Guilds Machine Shop Engineering examinations. Candidates should have industrial and teaching experience.

Salary: £1370 to £1550 per annum.

Further particulars and forms of application may be obtained from the PRINCIPAL, THE COLLEGE OF FURTHER EDUCATION, WOLVERTON, BUCKS, to whom completed forms should be returned as soon as possible. B 839

THE NIGERIAN COLLEGE OF ARTS SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING OF UNIVERSITY COLLEGE, IBADAN AT NIGERIAN COLLEGE OF ARTS SCIENCE AND TECHNOLOGY

Applications are invited for SENIOR LECTURESHIPS or LECTURESHIPS in:—

CIVIL ENGINEERING
MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING

in the Department of Engineering which has been recognised as the Faculty of Engineering of University College, Ibadan, in Special Relation with the University of London.

SALARY SCALES (CONTRACT), including 20 per cent contract addition and inducement addition of £240-£300 p.a. payable to overseas officers only:—

Senior Lecturer: £2457 by £90 to £2745 p.a.

Lecturer: £1500 by £75 to £2400 p.a.

Gratuity at £150 p.a. Free first class passages (up to a maximum of four adult passages) on appointment, termination and annual leave in U.K. Part-furnished quarters at low rental. Children's U.K. maintenance and other allowances. Appointments normally on contract for two sessions in first instance and renewable.

Pensionable appointments with consequently lower salary and without gratuity may be available in certain circumstances.

Detailed applications (6 copies), naming 3 referees, to SECRETARY, INTER-UNIVERSITY COUNCIL FOR HIGHER EDUCATION OVERSEAS, 29, WOBURN SQUARE, LONDON, W.C.1, from whom further particulars may be obtained. B 837

UNIVERSITY OF MELBOURNE

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above-mentioned position.

The salary range is £A2200 to £A2600 per annum. Commencing salary will be fixed according to qualifications and experience. Superannuation similar to F.S.S.U. in Great Britain will be provided.

Further particulars may be obtained from the SECRETARY, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36 GORDON SQUARE, LONDON, W.C.1.

Applications close in Australia and London on 31st MAY, 1960. B 843

BECHUANALAND PROTECTORATE

ENGINEER (MECHANICAL)

PUBLIC WORKS DEPARTMENT

To assist the Senior Engineer (Mechanical) in the running of the Government Workshops, transport and mechanical equipment.

Permanent or contract/gratuity appointment. Salary in range £928-£1848. Rented quarters. Free passages. Children's education allowance.

Candidates must be A.M.I.Mech.E. or possess B.Sc. in mechanical engineering with at least 5 years relevant experience.

Write DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1, giving full names, age, qualifications and experience, quoting BCD112/76/013/D5. B 840

THE UNIVERSITY OF LIVERPOOL

Applications are invited for the following awards:—

A limited number of UNIVERSITY FELLOWSHIPS in the Faculty of Engineering value £450 per annum, tenable for one year in the first instance, but renewable for a second year.

A limited number of Postgraduate Studentships, value £245 per annum, tenable for one year, but renewable for a second or third year.

The holder must pursue a full-time course of training in research within the University.

Applications, which should include particulars of age, academic career and qualifications, together with the names of three referees and quoting reference CV/EN and accompanied by published or manuscript work, should be received not later than 7th May, 1960, by the REGISTRAR, from whom further particulars of the conditions of appointment may be obtained. B 791

Graduates

are required by the

PRODUCTION GROUP
and the DEVELOPMENT AND ENGINEERING GROUP
of the UNITED KINGDOM ATOMIC ENERGY AUTHORITY

for interesting and responsible posts in

TECHNICAL MANAGEMENT — **PRODUCTION MANAGEMENT**

ENGINEERING DESIGN — **RESEARCH AND DEVELOPMENT**

IN THE FIELDS OF

CHEMICAL ENGINEERING — **CHEMISTRY**

ELECTRICAL ENGINEERING — **MECHANICAL ENGINEERING**

METALLURGY — **MATHEMATICS** — **PHYSICS**

Graduate apprenticeships are available for Engineers and Chemical Engineers. Salaries will be in the range £550-£1,185 with prospects of promotion to more senior posts before the maximum of the scale is reached. All appointments are permanent and pensionable.

Vacancies exist at the following establishments

CAPENHURST (Near Chester) • **CHAPELCROSS** (Annan, Dumfriesshire) • **CULCHETH** (Nr. Warrington, Lancs.)

DOUNREAY (Thurso, Caithness) • **RISLEY** (Near Warrington) • **SPRINGFIELDS** (Near Preston)

WINDSCALE AND CALDER
Sellafield, Cumberland

Groups' representatives visit Universities from time to time. If you are interested in a career with the U.K.A.E.A. please get in touch with your Appointments Board Secretary or write direct to:

Senior Recruitment Officer
UNITED KINGDOM ATOMIC ENERGY AUTHORITY
Risley, Warrington, Lancs.

B 825

TECHNICAL PLANNING AND PROGRAMMING

The Technical Secretariat of the Development and Engineering Group has vacancies for engineers, physicists, chemists, metallurgists and mathematicians. The responsibilities of the branch include the planning and co-ordination of various aspects of reactor systems development; the preparation of programmes for the Group; the marshalling of information from various sources and its co-ordination and presentation in a form suitable for top management; and economic studies in relation to programme proposals for future reactors and associated plant such as fuel fabrication and processing plants.

An honours degree in physics, metallurgy, mathematics or chemical, electrical or mechanical engineering or corporate membership of a senior professional institution together with at least 3 years' relevant industrial or research experience is required. All applicants should have a broad understanding of applied science and the ability to interpret and present information in a form acceptable to top management. A wide background of experience would be an asset particularly if it included operational research, technical economics or programming.

Starting salaries will be assessed on scales between £1285 and £1825 according to age, qualifications and experience.

Contributory Superannuation.
Staff housing scheme.
Send postcard for application form, quoting reference 210/J2, to
Recruitment Officer,
UNITED KINGDOM
ATOMIC ENERGY AUTHORITY
(D. and E. Group Headquarters),
Risley, Warrington, Lancs.

Closing Date: 9th May, 1960

B 833

BARROW-IN-FURNESS EDUCATION COMMITTEE
CENTRAL COLLEGE OF FURTHER EDUCATION

Required in September, 1960, LECTURER to teach THERMODYNAMICS up to Higher National Diploma level. Salary scale £1370 to £1550.

Application forms, obtainable from W. G. BATE, CHIEF EDUCATION OFFICER, EDUCATION OFFICES, BARROW-IN-FURNESS, should be returned not later than 29th April, 1960.

LAWRENCE ALLEN,
TOWN CLERK.

TOWN HALL,
BARROW-IN-FURNESS. B 792

AIR MINISTRY

AIR MINISTRY require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1095 at 34 or over, thereafter rising to max. £1260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. Five-day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service. Quals. and experience:—

(i) (*a*) University degree or equiv. diploma in electrical and/or mechanical engineering with at least 2 years apprenticeship; or (*b*) Graduate or corporate member of I.E.E. with at least 3 years apprenticeship; or (*c*) Graduate or corporate member of I.Mech.E. appreciable electrical engineering experience with at least 3 years apprenticeship; and

(ii) Have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45.

Forms from MINISTRY OF LABOUR, TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting D.158/OA. B 531

British Oxygen Gases Ltd.

have the following vacancies in their development group. The work is in connection with the development of equipment used in the medical field, for anaesthesia, oxygen therapy, resuscitation and automatic ventilation.

Development Engineer

Applicants should have a recognised technical qualification, preferably of pass degree or equivalent standard, as well as sound previous experience of design and development or experimental work in an appropriate direction. Familiarity with mechanical devices, scientific apparatus (not exclusively optical), instrumentation techniques, or systems involving the transfer of fluids would be an advantage.

Technical Assistant

Applicants should possess an O.N.C. or equivalent and have had some experience of test and experimental work of a nature parallel to that indicated above for the Development Engineer post.

APPLY IN WRITING TO PERSONNEL MANAGER,
British Oxygen Gases Ltd.,
SPENCER HOUSE, 27 ST. JAMES'S PLACE, LONDON, S.W.1.

B 735

MILLING MACHINE OPERATOR

MILLING MACHINE OPERATOR required by Ministry of Labour for appointment as Instructor (Unestablished) at the Government Training Centre, Letchworth, Herts. Applicants must be British subjects who are (*a*) experienced and fully skilled, (*b*) able to teach their trade, (*c*) supervise the work and maintain control of trainees engaged in their trade. They should have undergone the training usual in their trade followed by at least 5 years practical experience. An experimental tool room miller should be likely to prove suitable.

Applicants should preferably possess O.N.C. or C. and G. Certificate, or equiv. quals. where appropriate. Selected applicants will be required to pass a Theoretical Test before appointment. Commencing salary (at age 28 and over) £775 rising by annual increments to £900 p.a.—Write for application form to EMPLOYMENT EXCHANGE, LETCHWORTH, within 7 days. B 828

DRAUGHTSMEN

DRAUGHTSMEN required by Royal Arsenal Estate, WAR OFFICE, Woolwich, S.E.18, with experience in either (*a*) building construction in brick, concrete or steel; or (*b*) installation of plant and associated services. Candidates must have had appropriate practical experience and possess O.N.C. or equiv. qual. Salary £570 (age 21) to £783 (age 28) rising to £900. Five-day week of 42 hours (including meal breaks). 18 days annual leave plus public holidays. Payment for overtime and sick leave.

Applications giving details of training and experience to THE SECRETARY, ROYAL ARSENAL ESTATE, WOOLWICH, S.E.18, or to any Employment Exchange quoting Westminster 1127. B 829

ROYAL NAVAL COLLEGE, GREENWICH
ASSISTANT PROFESSOR OF APPLIED MECHANICS

Pensionable post for man at least 31 on 1.1.60 with high academic qualifications in Engineering, and teaching and research or industrial experience. Advanced knowledge of structural design and strength of materials, and good mathematical ability desirable. Duties: lecturing, design of experiments, and supervision of student research. Research facilities available. Secondment from Scientific Civil Service considered. Appointment in January, 1961, or earlier. Salary £2400-£2700. Starting salary may be above minimum. Single accommodation may be provided. Write CIVIL SERVICE COMMISSION, 17 NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting 8/5128/60. Closing date 17th May, 1960.

B 838

THE BOARD OF GOVERNORS

THE HAMMERSMITH AND ST. MARK'S HOSPITALS

DU CANE ROAD, LONDON, W.12

APPOINTMENT OF CHIEF ENGINEER

Applications invited for the appointment of CHIEF ENGINEER of the Hammersmith and St. Mark's Hospitals, a postgraduate general teaching group of hospitals. Candidates must hold corporate membership of the Institution of Mechanical Engineers or an equivalent qualification in mechanical engineering. A recognised qualification in electrical engineering would be an advantage. Salary scale £1375 by £45 (5) to £1600 p.a. plus £50 London Allowance. A gratuity of up to 10 per cent of salary will also be payable for hours worked in excess of normal 38-hour week. An additional payment will be made for supervisory duties for other authorities on the Hammersmith Hospital site. The successful candidate will be required to take up his duties on the 1st November, 1960.

Full details of duties and conditions of service may be obtained from the SECRETARY OF THE BOARD. B 831

THE UNIVERSITY OF LIVERPOOL

Applications are invited for the following posts in the Department of Civil Engineering:—

TWO POSTS OF LECTURER. The initial salary will be within the range £900-£1650 per annum, according to age, qualifications and experience.

DEMONSTRATOR. The initial salary will be within the range £600-£650 per annum, according to age, qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, and quoting reference CV/E, should be received not later than 28th May, 1960, by the REGISTRAR, from whom further particulars of the conditions of appointment may be obtained. B 826

CITY OF NOTTINGHAM

APPOINTMENT OF CITY ENGINEER AND SURVEYOR

Applications are invited from persons who have the necessary experience and qualifications for the appointment of CITY ENGINEER AND SURVEYOR at a salary of £3340 rising by one increment of £115 and two further increments of £110 to £3675 per annum.

The gentleman appointed will be required to devote the whole of his time to the duties of the office and will not be permitted to hold any other appointment or engage in any other work.

The appointment carries superannuation and the selected applicant will be required to pass a medical examination and to contribute to the Superannuation Fund.

Applications stating age, previous experience and present position accompanied by two testimonials and the names of two persons to whom reference can be made must be delivered to me not later than the last post on the 18th May in an envelope endorsed "CITY ENGINEER."

T. J. OWEN,
TOWN CLERK.

THE GUILDHALL,
NOTTINGHAM. B 855

APPOINTMENTS OPEN

ENGINEER

ENGINEER required for Development work on Gas Turbine Fuel Systems and Motor Vehicle Turbochargers. Candidates with a degree and suitable previous experience would be preferred. Enquiries should be addressed to the PERSONNEL MANAGER, SIMMS MOTOR UNITS LTD., OAK LANE, EAST FINCHLEY, LONDON, N.2. B 836

POWER HOUSE SUPERINTENDENT REQUIRED

To supervise oil-fired B. & W. installation, 70,000 lb. capacity. Responsibilities include Air, Hydraulic, and D.C. generation and distribution. Experience in supervisory position essential, first class B.O.T. or Naval Certificate desirable. Contributory Pension Scheme in operation. Write for application form, giving age, present position, and salary required to WORKS' ENGINEER, AVON INDIA RUBBER CO., LTD., MELKSHAM, WILTSHIRE. B 812

PATENTS ASSISTANT

British subject with knowledge of engineering terms and wide interest in Engineering required for work in connection with patent applications, including editing translations of engineering patent specifications. O.N.C. or H.N.C. in Engineering an advantage. Education at least to G.C.E. standard in English and Mathematics.—Apply in own handwriting with details of age, education, subsequent career and salary sought, to BOX 204, REYNELLS, 44 CHANCERY LANE, W.C.2. B 845

SENIOR AND INTERMEDIATE STRESSMEN

Expanding Aircraft Manufacturing Company situated in a pleasant part of the South of England require SENIOR AND INTERMEDIATE STRESSMEN AND ONE SENIOR STRESSMAN FOR TECHNICAL LIAISON AND APPROVAL OF CONCESSIONS. Also required is an Assistant Chief Aerodynamicist and two Senior Aerodynamicists. Salaries offered will be according to qualifications and experience and will range from £900 to £1500 for the Senior, Intermediate and Concessions Stressmen; £1300 to £1500 for the Assistant Chief Aerodynamicist and £1000 to £1300 for the Senior Aerodynamicists. New houses to rent will be offered to successful applicants.—Please send full particulars of experience, etc., to BOX AC 16652, SAMSON CLARKS, 57/61, MORTIMER STREET, LONDON, W.1. G 881

DRAUGHTSMEN

Four required by Tyneside Power Station Contractors, able to work with minimum supervision and having experience in either (*a*) Electrical Diagrams, Cable Layouts or Signalling. (*b*) Plant Layouts, Steam and Feed Pipework, etc., or (*c*) Structural Steel and/or Reinforced Concrete.— Write fully in first instance to CHIEF DRAUGHTSMAN, BOX B 770, Offices of ENGINEERING.

DESIGN DRAUGHTSMEN

Vacancies exist in a South of England Aircraft Manufacturing Company for SENIOR AND INTERMEDIATE DESIGN DRAUGHTSMEN, DRAWING OFFICE PROGRAMME ENGINEERS AND TEST HOUSE ENGINEERS. Salaries offered will be according to qualifications and experience and will range from £850 to £1250 for Senior Draughtsmen and Programme Engineers; £700 to £900 for Intermediate Draughtsmen and £700 to £1000 for Test Engineers.—Please send full particulars of experience, etc., to BOX AC 16656, SAMSON CLARK, 57/61, MORTIMER STREET, LONDON, W.1. G 880

THE REED PAPER GROUP

requires a

PROJECT ENGINEER

for the Steam Section of the Group Engineering Department. Applicants, aged 23-30, should possess H.N.C. or equivalent and have drawing office experience, together with experience in any of the following fields: Boiler Plant, Turbine Plant, Steam Distribution, Heating and Ventilating.

Excellent conditions of service include non-contributory pension scheme and assistance with house purchase.

Applications, giving age, qualifications, experience and quoting reference PE/GE/01 should be addressed to:—

THE GROUP PERSONNEL OFFICER,
ALBERT E. REED & CO. LTD.,
LARKFIELD, Nr. MAIDSTONE, KENT
B 815

OVERSEAS APPOINTMENTS

SIMON-CARVES LIMITED

REQUIRE

MECHANICAL ENGINEERS for overseas contracts. Applications are invited from men between 30 and 40 years of age who have experience in the erection and installation of electrical and heavy mechanical engineering plant, including H.P. compressors, pipelines and vessels. A.M.I.Mech.E. or similar qualification desirable.

Applications, quoting Ref. No. 32 with details of age, experience and qualifications should be forwarded to CONTRACT LABOUR DEPT., SIMON-CARVES, LTD., CHEADLE HEATH, STOCKPORT. B 803

INDUSTRIAL ENGINEER

AN INTERNATIONAL FOOTWEAR MANUFACTURER and DISTRIBUTOR require the services of an INDUSTRIAL ENGINEER.

Applicants should be capable of preparing drawing board layouts of new factories and extensions to existing factories based on latest methods of material handling and work flow.

The successful applicant would be expected to have a basic knowledge of electric power, lighting distribution and installations; a basic knowledge of methods study and have a plant engineering background.

Some knowledge of the French language would be advantageous.

Location will be in modern offices in Oxford Street, W.1, with the opportunity of occasional visits abroad as work requires.

Good salary with life cover and pension scheme will be offered to the right man. Write in first instance to the PERSONNEL MANAGER, 151, OXFORD STREET, LONDON, W.1. B 806

CENTRAL ELECTRICITY GENERATING BOARD

Southern, South Western and South Wales Region

Research and Development

PORTISHEAD LABORATORIES · SOMERSET

Applications are invited for the following posts based at new laboratories at Portishead.

MECHANICAL ENGINEERS

The work will involve both full-scale and rig investigations into burner design and development, thermal stresses, vibration and other troubles associated with power station plant in the Region. Some experience in flow or temperature measurements is preferred.

Two posts are available:—

(*a*) REGIONAL VACANCY NO. 56 (*b*) REGIONAL VACANCY NO. 57

(*a*) For the senior post an Honours Degree in Mechanical Engineering and several years' varied experience, preferably of a research nature, is required.

(*b*) For this post a recently qualified man with H.N.C. would be considered.

The salary ranges are:—

(*a*) £1090 to £1445 (*b*) £735 to £1170

There are excellent opportunities of promotion in the Board's rapidly expanding Research and Development organisation.

Applications, clearly stating post applied for, on form AE6/ACT, obtainable from the

Regional Secretary, (Ref. E) Southern, South Western, and South Wales Region, Central Electricity Generating Board, 1 Eaton Crescent, Bristol, 8

to be returned by not later than 6th May, 1960, accompanied by any additional information thought necessary. B 834

AIR CONDITIONING ENGINEER AUSTRALIA

A leading air conditioning and refrigeration company in Australia with prominent local and overseas affiliations requires an Air Conditioning Engineer for a senior position.

The company, which is a subsidiary of one of the largest manufacturing groups in the country, produces a full range of compressors, coils, heat exchangers, cooling towers and both packaged and central system air conditioning plants, and is currently undergoing an expansion programme designed to keep pace with the growth of the industry in Australia.

They are seeking a man with qualifications along the following lines:—

(1) To hold an Engineering Degree or equivalent, with preferably five to seven years full-time experience in the air conditioning industry.

(2) To be experienced in design and application of air conditioning equipment and systems.

(3) To have had practical field experience in the installation of large systems, particularly on the refrigeration and control side.

(4) To be capable of assisting in the training of Junior and Graduate Engineers who already have some experience in the air conditioning field.

The successful applicant would be required to take up appointment in Melbourne, where the company's Head Office is located.

Salary would be subject to negotiation ranging up to £A2500 or even more for a person with commensurate qualifications and experience.

Applications will be treated in strict confidence. They should be by letter setting out age, qualifications, experience and appointments held, addressed to:—

THE LONDON MANAGER,
EMAIL LIMITED,
BRITISH COLUMBIA HOUSE,
1-3 REGENT STREET,
LONDON, S.W.1 B 852

GKN

OPERATIONAL RESEARCH

There are a number of vacancies for honours graduates in the two Operational Research Units of the Guest, Keen and Nettlefolds Group of Companies. Mathematical statisticians, mathematicians, physicists and engineers are required to investigate and find solutions to the problems that occur in a large industrial group.

Applicants must have a good honours degree, and be younger than 28. Applicants should state a preference for a post in the Midlands Unit at Wolverhampton, or the South Wales Unit at Cardiff.

PRESENTATION OF TECHNICAL INFORMATION

THE GROUP RESEARCH LABORATORY offers an interesting post in its Liaison and Information Division to a young man with some experience in TECHNICAL JOURNALISM.

The successful applicant will be responsible for editing a technical journal and for writing and producing a 6-monthly progress report on the work of the Laboratory. Both publications are distributed throughout the Group which consists of over 80 companies engaged in steelmaking and many forms of engineering.

Some technical knowledge and the ability to present technical information in an interesting and understandable form are essential.

Applications giving details of qualifications, age, experience, etc., should be addressed to :—

THE RECRUITMENT OFFICER, G.K.N. GROUP RESEARCH LABORATORY, BIRMINGHAM NEW ROAD, LANESFIELD, WOLVERHAMPTON B 841

CHIEF DRAUGHTSMAN

required in established Development Department handling design and installation of a wide variety of plant for carbon black manufacture. Experience of this particular industry not required.

This appointment will be attractive to draughtsmen seeking opportunities to accept responsibility and obtain advancement with a young and expanding Company.

Applicants should have a sound basic practical and theoretical training and be capable of taking part in a wide variety of plant and engineering projects, should hold H.N.C. or higher qualifications and have drawing office supervisory experience.

FIVE-DAY WEEK

STARTING SALARY IN RANGE OF £1100 TO £1200 P.A.

Apply stating age, experience and qualifications to:—

PHILBLACK LIMITED

SEVERN ROAD, AVONMOUTH, BRISTOL.

for the attention of the WORKS ENGINEER B 858

WIMPEY

Applications are invited from

QUALIFIED ENGINEER/DESIGNERS

for reinforced concrete design in LONDON OFFICE.

At least three years' design experience essential and preference will be given to applicants who have also had site experience.

Hours 8.45 a.m. to 5.15 p.m., five-day week; Staff Restaurant; pension fund after probationary period.

Written applications to:—

GEORGE WIMPEY & CO., LIMITED,
27, Hammersmith Grove, London, W.6.
Ref. 950 F.

B 832

RESEARCH DEPARTMENT OF BRITISH RAILWAYS

British Railways are expanding the scientific research staff in their laboratories at Derby and have vacancies in the following grades:—

(1) **SCIENTIFIC OFFICERS GRADE I:** maximum salary £1150 per annum for work on:—

(*a*) Rolling stock including the study of the riding of vehicles and the measurement and evaluation of dynamic stresses in them, performance of bearings, etc.

(*b*) Marshalling and the movement of wagons, transit and vibration shocks, the measurement and computation of design factors needed for mechanised yards.

(*c*) Electronics—providing instruments needed in the above fields; a sound understanding of electrical fundamentals essential, together with a knowledge of modern measuring techniques.

Candidates for the above positions must have a good Degree and/or Professional qualifications, and have previous experience in engineering or research.

(2) **SCIENTIFIC OFFICERS GRADE 2:** salary £698 per annum rising to £1034 per annum, depending on previous experience, for work on:—

(*a*) The assessment of the strength of bridges and structures, including measurements of dynamic and static stresses.

(*b*) The development of vacuum braking systems, studies of air flow over vehicles and structures, including some Wind Tunnel work.

Candidates for these positions must have a good degree but previous experience in research is not essential.

(3) **SENIOR TECHNICAL ASSISTANTS:** salary range £875 per annum rising to £1034 per annum for work in most of the fields previously mentioned, but including work on permanent way problems such as long welded lengths, rail stresses, formation loading, etc.

Candidates must be in possession of the Higher National Certificate, with appropriate engineering training, preferably with Graduate membership of one of the leading Engineering Institutions. Some experience of experimental procedure an advantage.

All applicants will be in competition with Railway Staff, and must pass the Railway Medical Officer if selected for one of these posts. Selected applicants will be eligible for membership of the Superannuation Fund, and to certain travel facilities, after serving a probationary period.

Applications to be sent to:—

DIRECTOR OF RESEARCH (BRITISH RAILWAYS),
BRITISH TRANSPORT COMMISSION,
222 MARYLEBONE ROAD,
LONDON, N.W.1 B 824

DESIGN ENGINEERS

required for work on the design of large modern Water-tube Boiler Plant, involving problems in combustion engineering, heat transfer and fluid flow. Experience in one or more of these fields is a necessary qualification, and an engineering Degree would be an advantage but is not essential.

Full particulars, stating age, qualifications and past experience, should be sent to:—

CHIEF DESIGN ENGINEER
JOHN BROWN LAND BOILERS LTD.
WHITECROOK WORKS
CLYDEBANK B 816

BOILER HOUSE SUPERINTENDENT

B.I.P. CHEMICALS LTD., require at their Oldbury group of factories a Superintendent to take charge of a new and modern boiler house, supplying steam for process and generation. Applicants should be fuel technologists and have been in charge o fa modern boiler house of not less than 80,000 lb./hr. capacity and be conversant with up-to-date boiler control and instrumentation. The Company offers good conditions of employment and has a generous Pension and Life Assurance Scheme.—Applications should be made in writing giving full details of qualifications and experience to:—

PERSONNEL MANAGER,
B.I.P. CHEMICALS LTD.,
POPES LANE,
OLDBURY, BIRMINGHAM.
B 755

MECHANICAL ENGINEER

A large national Company has a vacancy for a Mechanical Engineer in each of the following centres:—

NEWCASTLE
GLASGOW
MANCHESTER
WOLVERHAMPTON

The Company is an expanding one and future prospects are very bright. The need is for good calibre men aged 28/30 with experience in the heavy engineering or chemical fields. Candidates should preferably have at least an H.N.C. in Mechanical Engineering, or M.O.T. 1st Class Certificate (Steam and Diesel) supported by an engineering apprenticeship. Please send brief details to BOX B 835, Offices of ENGINEERING.

STRESS ENGINEER

DAVY AND UNITED ENGINEERING COMPANY LIMITED

the largest producers and designers of rolling mill equipment in Great Britain require a Graduate Mechanical Engineer with experience of stressing techniques to expand and develop an existing stress section.

He will be responsible to the Chief Engineer for the development of standard analytical approach to general design problems. This work will entail the theoretical analysis of dynamic machines and structures subjected to impact and thermal loading. Complete research facilities exist for fundamental investigations into problems encountered. These facilities include a field research team equipped to carry out stress measurement on working components and a research workshop together with a photo-elastic bench. Knowledge of heavy welded fabrication techniques would be an advantage but is not essential.

Comprehensive amenities, Superannuation Scheme.

Apply with full details of age, experience and qualifications to:—

PERSONNEL DEPARTMENT,
DAVY AND UNITED
ENGINEERING COMPANY LIMITED
DARNALL WORKS
SHEFFIELD, 9 B 814

PROJECT ENGINEER

George Angus and Company Limited wish to appoint to their Management Staff a QUALIFIED ENGINEER with a production or general engineering background and knowledge of Textile Plastics/Rubber manufacture.

He will be responsible for advising on new projects and for setting up departments to manufacture products outside our present range. This will involve purchase and lay-out of plant and training of operatives. Assistance from other department heads will be available but the Project Engineer will be expected to take the initiative and to co-ordinate activities concerning the manufacture of new products.

This is a new appointment offering good prospects of advancement in an expanding Group to an Engineer (age 30 to 40) who has ability to get things done through people and who wishes to broaden his experience of management problems. Initial salary in the range £1500-£1850; usual fringe benefits.

Please address applications to Appointments Officer,

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Companies

A Good Year and a Better Future

THE trading profit of the DELTA METAL group increased by more than a million pounds last year—to £3,757,102, a record for the Delta companies.

And the present financial year for the company has opened encouragingly. Trade is good, says the chairman, Mr. W. E. Ogden, and the greater concentration of effort by the employees is expected to overcome the effects of the 42-hour week.

By far the most important event in 1959 for Delta Metal was joining the aluminium and light alloy interests into a new company with the American KAISER ALUMINIUM AND CHEMICAL Corporation. At the time this was undertaken, special steps to develop alternative lines of production and thus counter the adverse effects on the profits of the aluminium company, JAMES BOOTH, caused by the defence cuts, were beginning to pay off.

But other moves were going on in aluminium and it was decided there should be a closer association with one of the primary aluminium producers. The Kaiser Corporation is the third largest aluminium producer in the United States, controlling a substantial capacity in fabrication, both in the US and overseas.

The new Anglo-American company, JAMES BOOTH ALUMINIUM, was created equally as a £10 million concern. The former James Booth and Company assets, valued at £4,900,000, were transferred plus £100,000 from Delta Metal. The Kaiser Corporation then subscribed £5 million for the re-equipment and development of the Kitts Green works.

The management of the new company stays, by agreement, with Delta. With the massive programme of new facilities, already widely reported, they will be well placed to serve the markets anticipated in building, chemicals, in all forms of transport and in consumer goods.

On Investing £2½ Million

The sale to STANDARD-TRIUMPH INTERNATIONAL by HALL ENGINEERING (HOLDINGS) of their Motor Body Division, and the later sale of their office furniture making interests, realised £2,500,000 in cash.

Mr. P. C. Hall, chairman of the company, explains in his annual statement that the money is to be used for the expansion of a number of departments of the group, for the widening of the activities of Hall Engineering, and for the buying of businesses which will assist the functions of the group.

The new shape of the Hall Engineering group is one of three main divisions.

HALL & PICKLES Limited, making high speed and alloy tool steels, stainless steels and wires, cutting and mining tools and engineers' small tools, electrical resistance alloys and other products. They have now recovered from the effects of the 1958 recession. The company are also stockholders of mild steel and free cutting steels. Faced with heavy demand for mild and bright steel the directors are examining the possibility of establishing more stockholding facilities in other parts of the country.

The BRITISH REINFORCED CONCRETE ENGINEERING COMPANY Limited produces welded steel fabric for reinforcement for concrete structures and roads and also undertakes on a fee basis the design of reinforced concrete structures and civil engineering projects.

HALL ENGINEERING Limited includes aircraft wind tunnels, dies for large press tools and atomic work in the products of its Shrewsbury factory.

A Major AEI Order for South Africa

Electrical equipment valued at about £2,750,000 is to be manufactured for use on the South African railways by ASSOCIATED ELECTRICAL INDUSTRIES Limited.

The equipment will be traction motors, control gear, lighting and heating. It is to be installed in 113 motored coaches to be built by the UNION CARRIAGE & WAGON COMPANY (PTY) Limited. The greater part of the work by AEI as the principal sub-contractors will be done at the Manchester and Sheffield works. The lighting equipment will be supplied by the AEI LAMP AND LIGHTING Company from the Hereford works.

The coaches are to be used in multiple with the 105 coaches supplied during 1957-59 which were also AEI equipped. Only minor changes have been introduced to the equipment.

Since the coaches will operate on the suburban and inter-urban services of the Cape Western and Reef sections of the line, altitudes of 6,000 ft are encountered. To give the motors adequate cooling they are not only self-ventilated but are fitted with axial-blow fans to give additional cooling under heavy load conditions.

The high voltage switchgear will be placed in a pressurised cubicle in the body of the coach. Filtered air will be blown into the cubicle, excluding dirt and dust and increasing the time between overhauls and preventing tracking of the insulation.

Report from a Competitor

A respected member of the opposition from abroad in the electrical engineering field is AEG (ALLGEMEINE ELEKTRICITATS-GESELLSCHAFT), of Berlin.

The annual report by the directors of AEG echoes those we have heard from chairmen at home. The downward trend in prices meeting rising costs is stressed and the AEG directors make the point that growing capacity, and need to use it, in the industrialised countries made it possible for the developing nations to increase "their technical and financial demands upon suppliers."

Employing 109,000 people in AEG and its subsidiaries, the group has a substantial investment in the future of its staff—it has 2,682 apprentices, 719 of them listed as technical and commercial.

The impact upon German firms of social contributions is considerable and AEG's voluntary social expenditure rose to 34·5 million Deutschmark. This covered Christmas bonuses, welfare payments, health protection schemes, accident prevention measures and holiday accommodation.

The turnover of the AEG company and its main subsidiaries (those in which AEG has more than a 50 per cent holding) rose last year to 2,153 DM, in round terms £185 million. The company's export ratio remained constant at 22 per cent.

The breadth of operations of a company of this size is indicated by the statement that the number of suppliers to the company and main subsidiaries has now reached 16,000.

Budget Reactions

A number of reactions from leading industrial figures followed the budget. Among them was the repeated observation that in leaving the investment allowance untouched, nothing had been done to prevent the resurgence of heavy engineering, playing its part in the expected increase in provision of new capital resources.

One of the sharper retorts to the budget came from Holland, where Mr. J. O. M. Fisher, (inset) chairman of the DRY DOCK OWNERS AND REPAIRERS CENTRAL COUNCIL, heard with bitter disappointment that no extra investment allowance is to be allowed to dry dock owners.

In a statement issued by the SHIPBUILDING CONFERENCE, Mr. Fisher described the absence of any concession as: "A bitter disappointment to an industry struggling hard in the face of severe competition from countries where investment in new dry docks is treated much more generously for taxation purposes than in the United Kingdom."

The representatives of the Dry Dock owners had asked for an increase in the investment allowance to 40 per cent, which is the figure available to shipping, and for the existing annual allowance of 2 per cent to be raised to 5.

Mr. Fisher must have felt the sting of the Chancellor's inaction the more keenly since he was at the time of the budget visiting ship repair installations in Belgium and Holland—installations that are in every way competitive with the British firms, and who have governments that set altogether more benevolent tax codes.

Sponsored Research on Rubber

The 1960 research grant of £42,000 made by the United States Rubber Research centre is to go in part to three British universities. They are Glasgow, North Staffordshire, and London (Imperial College).

Dr. Philip D. Brass, an associate of US Rubber Research, is to work from Paris in the administration of the grants. The universities of Utrecht, Liege, Strasbourg and Technische Hochschule of Aachen are also to benefit.

The research centre is supported by the international UNITED STATES RUBBER Company. Applied research is carried by the affiliated firms in Britain. They include US RUBBER INTERNATIONAL, LASTEX YARN AND LACTRON THREAD, of London, the NORTH BRITISH RUBBER Company, of Edinburgh, and the RUBBER REGENERATING Company, of Manchester.

Ford Chairman Attacks Roads Neglect

Sales equal to almost £1 million for every working day, production of the new Anglia car passing 950 a day and a trading profit of almost £34 million; these are the outstanding facts of a triumphant FORD MOTOR Company annual report.

Sales last year were 12 per cent better than in 1958, reaching £233 million.

Sir Patrick Hennessy, the chairman, reporting the post-war phase of development at Dagenham to be now in full operation, said that spending on capital investment last year was £12,748,948. The Ford company's fixed assets now stand at £70 million and contracts for capital expenditure are worth over £5 million.

This figure does not reflect the future spending of tens of millions at Halewood, Merseyside, where initial Ford plans are for the production of 200,000 cars a year. Engines, transmissions and certain other parts will at first be shipped from Dagenham and the company's suppliers but Halewood will be developed into a fully integrated car plant and its output stepped up.

With the company turning out 472,857 cars, trucks and tractors last year, the addition of the new plant at Halewood and the move of the commercial vehicle section to Langley, near Slough, one of the larger parts of the pattern of growing pressure on road space is plainly due for its own period of "explosive expansion."

It is natural that Sir Patrick should feel that the energy his and other car concerns are putting into meeting the desire of the ordinary family to have its own means of transport is not matched by the nation's road building programme.

The record in this, he says, is one of inertia and neglect. Massive arrears of road construction have accumulated.

The Ford chairman is perhaps unfair to the able staff of the Ministry of Transport when he says that Mr. Marples at last found that this country had the techniques, the equipment and the ability to build motor roads as good as any in the world.

He is entirely right when he says road building efforts must be intensified.

Increasing competition is seen as coming from American car firms in the export of smaller cars and car manufacture outside Europe and North America, relatively limited so far, will grow substantially.

With a wistful glance at the way in which the favourable economics of production at Dagenham in the area of the Thames estuary pointed to expansion there, Sir Patrick says that, with two other large car firms putting up factories on Merseyside, Ford has some concern that from local unemployment the pendulum may swing to labour shortage.

Apparently the Government takes the view this is not likely and Ford's—"can only hope that events will prove them right."

The Electron Beam as a Production Tool

There are many types of electron beam equipment. The design depends upon the application of the equipment which might be for any process requiring controlled heating.

THE electron beam as an easily controlled source of heat has developed over the last two years into something of a jack of all trades. It has been used for welding, melting, casting, refining, drilling and milling.

Electron beam equipment consists basically of an evacuated chamber, an electron gun, a voltage source for the gun.

The Electron Gun

The heart of any electron beam heating equipment is the electron emission system. There are many types available, and the one used depends largely on the application for which the equipment is intended. The types fall into two main categories: those producing columnar beams and those producing annular streams of electrons. Those systems which produce columnar beams consist basically of an emitting cathode, a focusing arrangement, and an accelerating arrangement, though the focussing arrangement may be combined with the other two elements. Fig. 1 shows a typical gun in which the cathode is a tungsten filament. The anode may be the workpiece that is being heated as in (*a*) or it may be a plate having an aperture to allow passage of the beam as in (*b*).

Pure metal cathodes of, say, tungsten or tantalum, are considered to be generally desirable in this type of application. This is unfortunate because other materials such as oxides or thoriated tungsten are much better emitters of electrons, but they are, however, easily contaminated by exposure to the atmosphere, evaporated metals or deposits of impurities, so that they are unsuitable for this work. Of the two pure metal cathodes, tungsten and tantalum, tungsten is preferred if the cathode is in the form of a filament, because a filament usually must be more or less self-supporting, and it retains its mechanical strength sufficiently to maintain its shape at the high temperatures (2,500° C) required for electron emission. Tantalum, on the other hand, has a better electron emission than tungsten at any given temperature, and if the cathode is a solid shape, indirectly heated, then tantalum is the preferred material because of the better emission. The graphs of Fig. 2 illustrate these facts.

The gun shown in Fig. 1 can be used in applications where relatively low (less than 10 kW) powers are required. Its optical properties improve greatly as the accelerating voltage is increased, because the irregular field geometry resulting from the use of a filament is swamped by the intense field set up by the accelerating electrode. If higher power levels are required, along with reasonably good optics and with operating voltages less than 20 kV, a more elaborate design such as that shown in Fig. 3 should be used.

In this case, a tantalum block is used as the cathode. It is machined to a concave spherical shape, and the focusing and accelerating electrodes are very precisely shaped. The electric field geometry is relatively free from irregularities, and the resultant beam has good optical characteristics. High currents can be used with this gun, thus permitting high power levels.

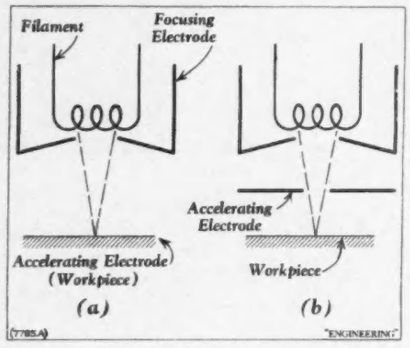
If an extremely small spot size is required, or a high penetrating power, it is possible to build comparatively simple guns with hair-pin filaments similar to those used in electron microscopes. Guns operating between 40 and 140 kV have been built in this manner, producing spot sizes as small as 0·010 in at a power level of 1 kW.

When the gun is located some distance from the work piece, or if very small spot sizes are required, it is necessary for provision to be made for further focussing after the beam has passed the aperture. This can be accomplished conveniently by the use of focus coils whose axial magnetic fields are parallel to the beam, and whose radial magnetic fields are symmetrical about the centre line of the beam. Several magnetic lens configurations are shown in Fig. 4.

In order to increase cathode life and to prevent gas discharges in the vicinity of the cathode, it is necessary to maintain a vacuum of 10^{-4} mm of mercury or lower in the gun. Since most applications of the process involve the evolution of gases, difficulties may be encountered if the gun is too close to the work piece.

To avoid these difficulties an emission system generating a constant velocity beam is the answer. The gun with its intense electric field can be removed to any distance from the source of the pressure bursts and, since the instantaneous pressure distribution during a burst is essentially a square law, it can be seen that the burst will be greatly attenuated by the time it reaches the gun. In addition, one or more apertures can be placed in the path of the beam to further reduce the flow of gases to the gun, and a small auxiliary pumping system can be placed close to the gun to remove the small amounts of gas that do reach the gun.

For some applications, such as floating zone refinining and ingot melting, an annular emission system has been used. Such a system is shown in Fig. 5. These systems are very much like that shown in Fig. 1 (*b*). They possess the advantage of simplicity and ease of scaling up. Their main drawback is that the cathode is so close to the work piece that discharges are unavoidable unless the work piece is very clean, and the cathode is subject to deposition of evaporated metals which poison it. Nonetheless, they have been used frequently and with some success.



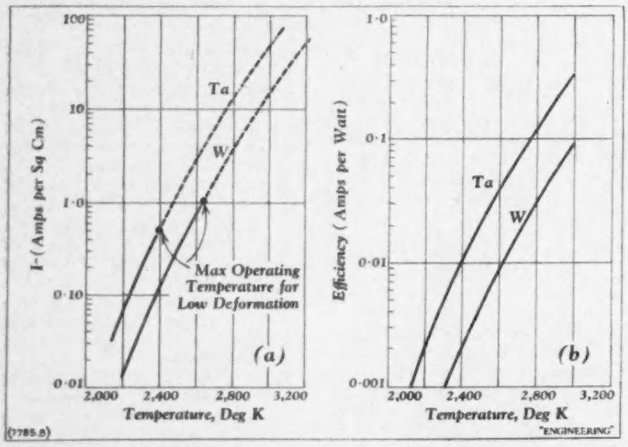
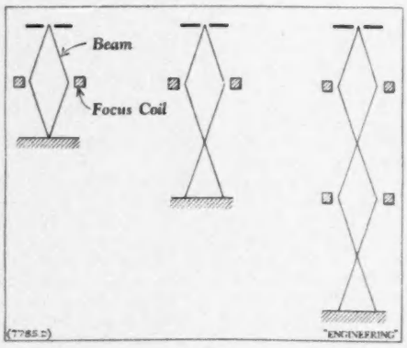


Fig. 1 (above) Simple electron gun configurations.

Fig. 2 (left) (a) Emission from tungsten and tantalum filaments. (b) Emission efficiency of heated tantalum and tungsten surfaces.

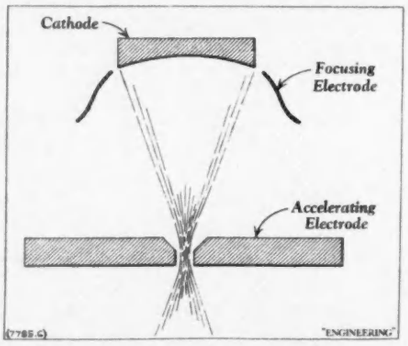
Fig. 3 (right) Electron gun with spherical cathode.

Fig. 4 (below) Magnetic focusing systems.



Construction

The materials of construction for electron guns must be compatible with both high vacuum and high temperature. Metals such as stainless steel or nickel are quite suitable for electrodes and filament supports, but they should be polished to minimise high voltage breakdown.



Insulators present somewhat more of a problem because small amounts of out-gassing can initiate breakdown and subsequent damage to the insulator itself. High alumina ceramics are reported to be satisfactory from the standpoint of out-gassing, though they should be glazed to prevent absorption and to make them easy to clean.

Power Supplies

If the equipment employs a gun producing a columnar beam with good optics, then the a.c. ripple on the power supply output should be kept down to a few per cent of the total voltage. This is particularly important where apertures are used, because the focal length of the beam is sharply dependent on voltage. If

the system is operating at a high power level, there is a great advantage in using a three-phase full-wave rectifying system because the ripple on the output is only 4 per cent without any filtering.

The ripple figure of 4 per cent is dependent upon a sinusoidal input wave to the rectifier. This rules out the use of saturable reactors for voltage control and also the use of silicon diodes in the rectifier circuits because they should be operated with inductances large enough to prohibit burn out currents during transient discharges. The ideal power supply for high power, well focused beams is, therefore, a unit using a variable auto-transformer for voltage control and vacuum tube rectifiers.

Grid control rectifiers, although cheap, cause such a severe filtering problem in smoothing their output that their use is usually avoided, except where the optical characteristics of the beam are of secondary importance, as in the case of the annular gun, where they can be used to advantage because of their cheapness and the fact that they lend themselves very well to fast acting automatic control.

Uses of the Electron Beam

Melting.—Large scale melting for producing ingots has been carried out successfully using an annular gun. A solid rod of the metal to be melted is lowered gradually through the annular gun structure operating at about 10 kV. Molten metal drips from the end of the rod into a pool of molten metal in a retractable mould. The molten pool is maintained by another annular gun above the pool whose focusing system directs electrons downwards.

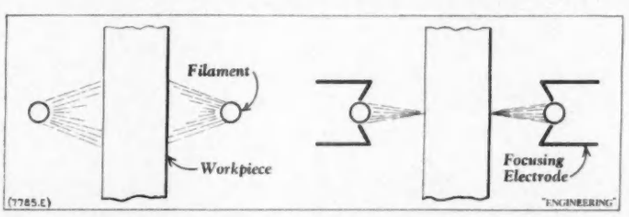


Fig. 5 (left) Annular electron guns.

Fig. 6 (right) An electron beam melting furnace.

Large (32 in) diffusion pumps are used to keep the pressure down to 10^{-4}mm of mercury in the face of out-gassing. Because of the danger of pressure bursts causing discharges, the power supply has to be designed to react instantly to load changes, thereby preventing damage to the equipment and the power supply itself.

A different approach to this problem is illustrated in Fig. 6. Instead of an annular gun, the gun produces a columnar beam of 60 kW power. The gun is positioned about 4 ft from the melting area and is further isolated by an aperture which inhibits gas flow to the gun.

In operation, a molten pool in a retracting mould is maintained by the beam. The metal to be melted is fed into the pool in powder form from a vibrating hopper.

Welding.—Electron beam welding offers the advantage of a contamination free weld, because of the lack of a contaminating electrode or a contaminating atmosphere. In addition to these major advantages, it is possible to control the diameter and power level in an electron beam to a much greater extent than can be accomplished with an arc. Smaller diameter welds can be made with the electron beam and much higher depth to width ratios can be obtained.

Tungsten, tantalum, molybdenum, titanium, hafnium, zirconium, uranium, beryllium, aluminium, nickel, stainless steel and carbon steels have been successfully welded by this technique in thicknesses up to ¼ in and more. Magnesium and chromium have not been successfully welded because of their high vapour pressure.

The simplest welders employ a tungsten filament behind a collimating disc. The filament is kept at about 5 to 10 kV negative with respect to the work which is earthed. Maximum current is usually of the order of 100 mA, allowing maximum power level of about 1 kW. Spot diameters range from $\frac{1}{32}$ to $\frac{1}{8}$ in. Typical gun-to-work distances are ½ to 1 in. This arrangement has the basic disadvantage that irregularities in the work will cause defocusing of the beam.

A modification of this scheme has the anode within the gun with the work electrically neutral with respect to the anode. This cuts out the effects of irregularities in the work and allows the gun to operate further from the work. Magnetic focusing is usually employed with this equipment. Typical electrical values with this type of gun are 20 kV, 3 kW, and spot sizes ranging from 0·01 in to 0·1 in. This layout makes it possible to interpose a separate vacuum chamber between the gun and welding chamber. This intermediate chamber has its own pumping system and makes the vacuum at the gun less dependent on the vacuum in the work chamber. Thus large gas bursts from the work can be tolerated without interrupting the weld.

Sintering.—High temperature sintering is generally done in resistance or induction heated furnaces. In both cases either a heating element or a susceptor must be elevated to a temperature higher than that to which the charge is to be subjected. This introduces serious problems as far as warpage, evaporation, and heat loss are concerned. A sintering furnace heated by electron bombardment makes it possible to heat the charge to a temperature higher than that of any other part of the system. The only heating element is the electron source and this can be maintained at a relatively low temperature. Also, the amount of costly refractory metal in the filament for the electron source is very small compared to that required for a resistance heating element or induction susceptor. The power requirement for an electron beam sintering furnace can be kept lower than that for the other two types because the power can be directed specifically at the charge.

An electron beam sintering furnace now in use for tantalum is capable of heating 1 lb of charge to about 2,200° C with an electron current of 5 A at 2,000 V in 15 minutes, or 2½ kW-hours per lb.

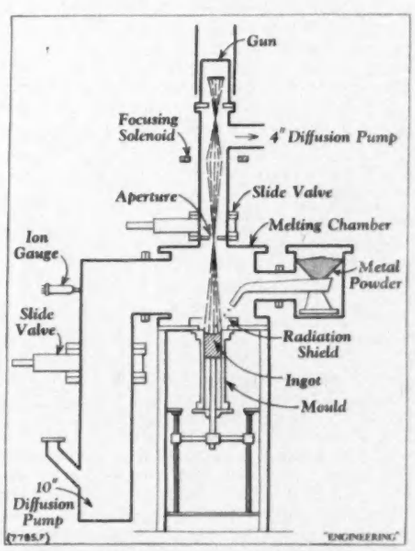
Zone refining.—The floating zone refining process using induction heating has become widely used, particularly in the last few years. It suffers from the limitation that very small heated areas are very difficult to obtain. This is very important in the case of refractory metals where the power required is high for a small zone and may be prohibitive for a large zone. Also it is important in many zone refining applications to control the power input very precisely. This again is not always easy to do with induction heating.

In order to obtain precisely controlled small zones for floating zone refining, a relatively simple annular electron beam source can be used. In a typical case, a loop of tungsten wire (0·010 to 0·025 in diameter) is wound about the rod, which is usually the anode. The filament and focusing plates are at the same d.c. potential. This arrangement has the feature of simplicity and relatively low power consumption. Difficulties often encountered are contamination of the melt from the tungsten filament by material distilled from the melt.

Metals with melting points up to 3,370° C have been successfully processed using this method. Molybdenum rods up to ½ in diameter have been processed, tungsten up to about ¼ in, and tantalum up to ¼ in diameter. The power supply to this type of equipment is usually about 500 mA at 10 kV.

This method of zone refining has the added advantage that its success is not dependent upon the resistivity of the refined material. Induction heating is generally not practical if the resistivity of the material is less than 0·1 ohm-cm. Electron beam floating zone refining can be accomplished even with good insulators such as sapphire. The process also makes it possible to melt extremely small diameter samples which are difficult to couple to with induction heating. Wires as small as 0·06 in diameter have been melted.

Single crystal growth.—A great deal of effort has gone into developing techniques for the growth of single silicon crystals. The most commonly used technique, the Czochralski technique, is capable of producing large crystals economically but it suffers from the limitation that the molten silicon comes in contact with the crucible material—usually quartz. Gasson has described an electron beam heated puller for silicon that overcomes many of the disadvantages of this technique. Four remotely located electron beam guns are focused on a polycrystalline silicon slab on a water cooled tantalum support. A pool of molten silicon is formed inside the solid silicon slab and no contaminating crucible material comes into contact with the metal. Using the same raw material in comparing the two procedures it was found that the oxygen concentration in the silicon was



10 times better in the case of the electron beam equipment. The guns are rated at 1 kW each for a total of 4 kW at 5 kV. The cathodes can be individually moved to change focal spots in order to preserve symmetry of the melt. Each beam heats an area of about 3 cm by 1 cm.

Another procedure is to feed a rod of silicon vertically upwards, to melt the top of the rod and to pull the single crystal from this molten arc. A molten pool can be maintained at the top of a ¾ in diameter rod with an electron beam power of 400 to 500 W.

Metallising.—Electron beam techniques are very useful for producing evaporated films of materials which cannot be heated in crucibles or on filaments. The equipment is very similar to that used for melting, with the exception that the power level is much lower and a button plate is substituted for the ingot mould.

The material to be evaporated is placed in the depression of the button mould and heated to evaporation temperature by a sharply focused beam. Coatings of tantalum 0·0005 in thick have been produced in this way with an evaporation time of less than one minute.

Acknowledgement is expressed to the NRC Equipment Corporation for material used in this article.

Cleaning Gases at High Temperatures

Cleaning hot gases would solve many industrial problems, not only for the prevention of atmospheric pollution, but also for gas utilisation.

By Dr. W. Strauss, CISRO, Chemical Engineering Section, Melbourne and Professor W. M. Thring, University of Sheffield

A MAJOR problem facing the process industries, for which there has been no really satisfactory solution, is the cleaning of process and waste gases at high temperatures, that is, temperatures above about 600° C. For example, if particles could be removed from the hot combustion gases passing to gas turbines, erosion of the turbine blades could be reduced to an acceptable level. Oxygen enrichment techniques too, could find more immediate widespread application in the steel industry if a simple and cheap method of reducing the amount of fume produced by oxygen lancing could be found. Furthermore, if industrial waste gases could be cleaned while hot, the buoyancy of the hot gases would carry any residual pollutants to the upper layers of the atmosphere. If, in addition, a gas cleaning process enables some of the heat in the waste gases to be recovered, the process will be more economical than some others in use.

Silverman and others[1] have investigated a slag wool filter bed, which, in the laboratory, has removed over 90 per cent of an artificially-prepared iron oxide fume consisting of sub-micron sized particles. Because of mechanical difficulties it has not proved so efficient on a pilot plant scale, and also, as the heat capacities of the fibres are so small, a slag wool filter bed cannot recover heat from the waste gases.

EXTENDED HEATING SURFACES

One of the present authors suggested[2] that a bed of refractory granules may act as a reasonably efficient dust and fume filter, and could be capable of regenerating some of the heat given up to the filter bed. Thus, by placing such a filter after the regenerator on each side of an open-hearth furnace, the combustion gases on the reversal cycle could be preheated before passing to the regenerator. A regenerator consisting of refractory granules has a greatly extended heating surface, making for highly efficient, forced convection heat transfer.

The fume collection efficiencies of beds of varying depths of crushed high temperature insulating brick were therefore measured with different gas flow rates, fume concentrations and gas temperatures. The apparatus used is shown in the accompanying diagram. Hot fume-laden gases entered the unit at the top, through an inlet pipe, with a venturi construction for measuring the gas flow rate. The gases then passed through the filter bed, retained on stainless steel gauze, in the cylindrical section of the unit, and out through the exit pipe in the base of the unit. The plant was designed so as to obtain an even flow through the filter bed. The sizes of the granules varied between 7 mesh and $\frac{1}{16}$ in, the average being about $\frac{1}{8}$ in. Details of the arrangement used for obtaining the hot gases from the open hearth furnace regenerator, and of the sampling technique, have been published.[3] Gas flow is controlled independently of the furnace by two fans and a control valve.

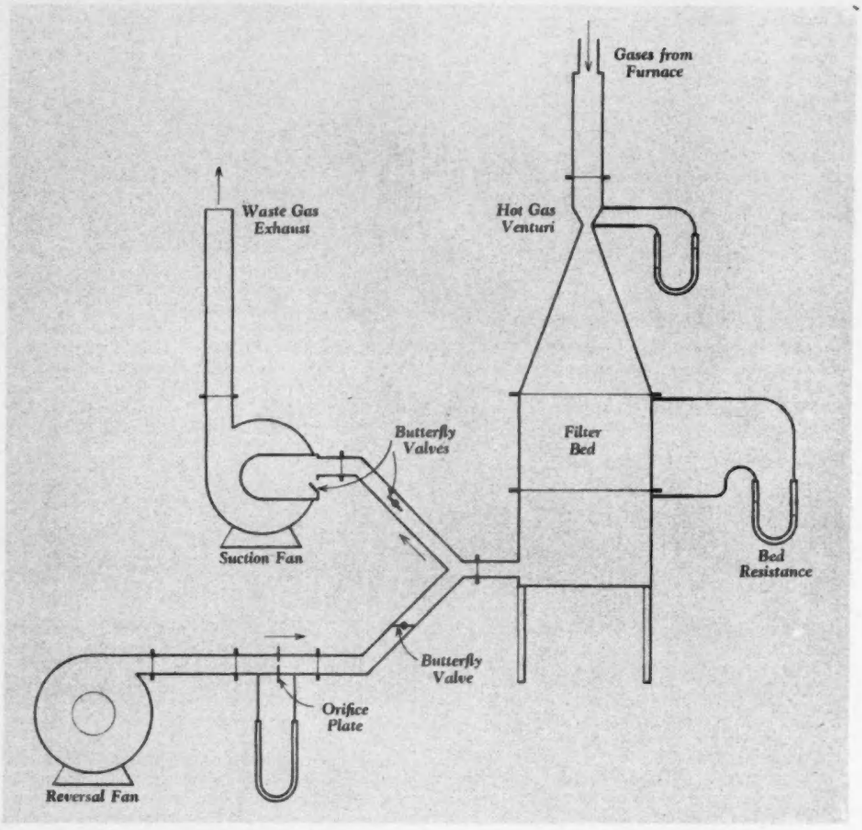
Some of the average experimental results for 3 in and 9 in filter beds are given in the accompanying table. In some cases the efficiency of the 9 in filter bed was better than 95 per cent, with a pressure drop through the bed of less than 3 in water gauge, and a face velocity of about 100 ft per sq. ft per min and a gas temperature of over 300° C.

It apears from the table that the thin bed is a relatively more efficient collector of fume than the 9 in bed. However, the face velocity for the thin bed is much higher (almost twice), and the trends of the experimental results indicate that higher velocities favour higher collection efficiencies. This suggests that impaction and interception are the predominant collection mechanisms. It was also found that a filter bed which was initially cold was a better collector of fine fume particles, such as are produced when oxygen is applied to a melt during steel making, than a hot filter bed. It is therefore suggested that at first, while there is a temperature difference between the hot gases and the cold bed particle surfaces, thermal precipitation plays an important part in depositing the first particles. Subsequently, when the bed has been heated, interception by the particles which have been initially deposited becomes predominant. An indication of the possible importance of thermal precipitation in collecting particles can be found by calculating the thermal force on a particle in its average position in an equivalent capillary based on the amount of free space in the filter bed. Einstein's equation[4] was used for this calculation, as it has been found suitable for sub-micron sized particles. Some exploratory experiments indicate that at face velocities greater than about 180 ft per sq. ft per min the collection efficiencies tend to fall off.

In these experiments the pressure drop through a 9 in filter bed varied between 2 in for a fresh bed, to 4 in water gauge for a bed which had been used, with reversing, on an open hearth furnace during four complete steel making cycles. Oxygen lancing was used for several minutes in the furnace during each of these cycles, giving very high fume concentrations. Because of the mild steel structure of the apparatus, it was not possible to test the collection efficiency of the filter for extended periods above 600° C, but the refractory material employed as a filter medium will withstand higher temperatures.

It appeared that increasing the gas temperature favoured collection, but as the temperature variation was small, the effect could not be shown to be highly significant. Higher inlet fume concentrations also assisted collection. This may be explained as a corollary of the collection mechanism proposed.

The authors wish to thank the directors of the Darwins Group for allowing the experiments to be carried out at their Toledo Steel Works, Sheffield. One of us (W.S.) is indebted to the Ministry of Power for a research bursary.



Pilot plant equipment flow sheet.

Average Efficiencies for Fume Collection

Bed thickness (in)	3	9
Average filter bed efficiency, per cent	68	79
Overall pilot plant efficiency, per cent	75	86
Specific efficiency per inch depth of bed, based on average efficiency, per cent	31	16
Average gas velocity ft per sq. ft per min	133	72
Average gas mass flow, lb per sq. ft per hr	280	175
Average gas temperature, °C	355	270
Average inlet fume concentration, grams per normal cubic metre	1·5	1·4

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[2] Thring, M. W., Brit. Pat. No. 12491/57.

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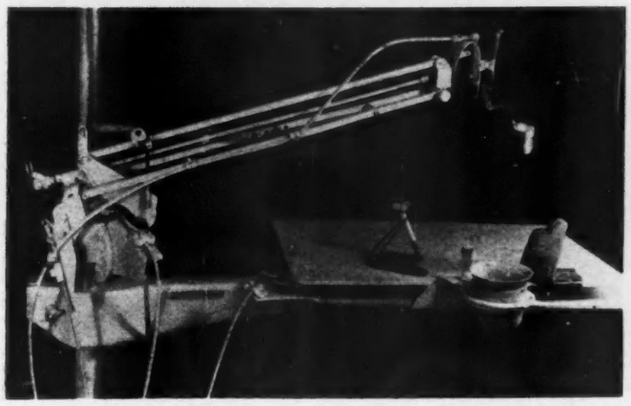
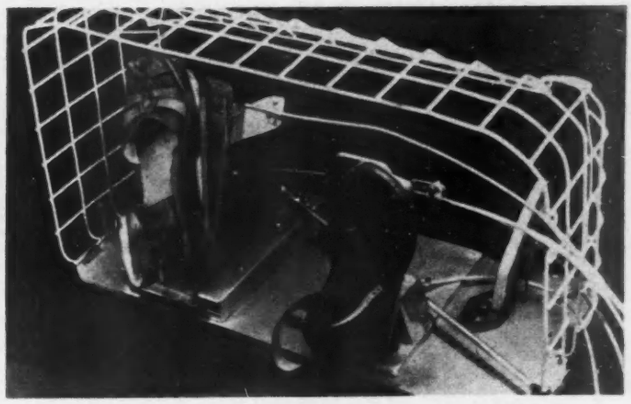
Eating with the Feet





Standard parts were adapted to make this foot-controlled feeding mechanism for a polio patient at a cost of only £50.

To help a polio patient, unable to use her hands, to feed herself by means of limited foot movements, two Coventry men, Mr. A. E. Harvey and Mr. J. Ainley, have constructed a pedal-operated mechanism. They took as a guide the type of remote-controlled handling tongs used in nuclear work, but their problem was that such an apparatus, made in the customary manner, would have cost about £1,000. By using standard components wherever possible, the cost has been kept down to £50. Thus, the foot controls are connected to the eating utensils by Bowden cables, the mechanical arm is an Anglepoise lamp bracket, and the hand is a car-type crocodile-jaw grip. Solderless nipples from motorcycle controls have also been incorporated. From these varied and easily obtainable items an apparatus has been built which not only enables the patient to manipulate feeding utensils such as a fork, spoon or beaker, but can also be used to hold a pencil and could easily be adapted to suit occupational objects such as painting pallets.

The mechanics of the device were, as can be seen from the illustration, simple enough, but the designers had one further problem to solve. It was found that the patient could not exert a force of more than 2 lb with her feet, and a force of from 2½ to 4 lb was needed to operate the equipment. This problem was overcome by spraying two coats of " Emralon 820," a resin-bonded dispersion of ptfe, on the inner cables and the sliding surfaces of the foot control. This low-friction material, made by Acheson Colloids Limited, Prince Rock Plymouth, reduced the average operating force required from 3 lb to 2 lb, the maximum the patient could manage.

Precision Work Gets Good Lighting

Uniform natural and artificial lighting has eliminated bench and machine lights in this toolroom.

In the new toolroom of the Aston Chain and Hook Company Limited, Erdington, Birmingham, individual bench and machine lighting has been eliminated by careful attention to both daylight and artificial light conditions.

Occupying the upper floor of a new two-storey building, the toolroom has a floor area of 2,200 sq. ft, and natural light is admitted through double glass windows and roof lights with a total area of 1,025 sq. ft.

Artificial lighting is by fluorescent " daylight " strips, giving an average light intensity of 30 lumens per sq. ft. At certain special machines and bench stations, and in the adjoining standards room, the illumination is raised to 50 lumens per sq. ft.

Without any bench or machine lights, the general level of lighting is sufficient for the most detailed work undertaken by the firm.

Reliability of Military Equipment

Equipment for the fighting services must, if it is to be effective, function immediately and correctly at the precise moment when it is needed. Much of it is extremely complex, and the problem of ensuring reliability is aggravated by the need for the equipment to be sorted for long periods. How to ensure that the necessary standard of reliability is met was the subject of a symposium held recently at the headquarters of the Federation of British Industries, and attended by representatives of the services, service Ministries, educational and professional institutions and manufacturers of equipment.

It is recognised that perfect reliability is unlikely ever to be achieved. This being so a standard of reliability for a particular item of equipment should be estimated in advance and compared with that which the users consider tolerable, having regard to development time, performance and acceptable level of maintenance.

In the setting of such standards, several problems arise. Designers are handicapped by lack of complete information, not only about the stresses to which their equipment will be subjected in use, but also about the behaviour of the products under these stresses. The need here is for factual information, which can only come from research into the environment, materials and components. Manufacturers must reduce the variability introduced by production processes despite the relatively small number of products needed.

To enable designers to carry out their part of the work, observations must be made of the materials, components, sub-assemblies and complete equipment, with full consideration of the environmental conditions under which the equipment will operate, and the information obtained must be channelled back in a form suitable for design purposes. So complex is the work of the designers that the job can only be done by large teams consisting of many specialists.

Given the design data, the designers must provide the manufacturers with precise specifications, based on the measured inherent variability of the production processes. In turn, the manufacturers must so organise that the processes are maintained at the agreed level. This is quality control carried to a greater degree than hitherto. Managements must take an overall view of the whole problem and of the requirements at each of the stages named, so that the proper flow of information and corrective action takes place.

The need for a new class of reliability or quality engineer whose field of supervision would embrace design, production and inspection was suggested. On the other hand, if the designers, production engineers and inspectors each had the same wide knowledge of the approach needed to ensure equipment reliability, the same result might be achieved. It appeared that the actual method of achieving the desired result would depend upon the local factors, including the availability of suitable men. In any case, the problem constitutes a new managerial responsibility.

Consideration is being given by the organisers of the symposium to the question of what further steps can be taken to encourage advancement, and though the aim will be, as it was at the symposium, to deal with service equipment, any developments which take place could be of considerable value in the civilian field. There are, in fact, certain civilian applications where reliability is vital—fire and rescue services for example, or industrial processes where a sudden breakdown might be costly or even dangerous. In any case, a high standard of reliability in any product is always desirable. It might reduce operating costs, and certainly would not increase them; maintenance costs would certainly be lowered.

On the Shelf

By Frank H. Smith

HERE's another chapter from my forthcoming *Hints to Telephone Users*. I know from conversations I have had with others that many people are antagonised from the start by hearing a voice the other end say "Mr. Flapdoodle speaking." That "Mr.", for some unknown reason, makes my hackles rise. It is so easy to say "My name is Flapdoodle," and unless you are a counter-tenor the Mr. should be obvious. On the other hand, I do wish women would put (Mrs.) or (Miss) after their signatures. In a profession like librarianship sex-differentiation (on paper) can be quite difficult. That, as a matter of fact, is why I use Frank and not my full name of Francis. I got tired of being addressed as Miss Francis Smith by Americans (who don't seem to know the difference between ces and cis).

Van Nostrand (358 Kensington High Street, London, W14) March announcements include Nesbitt's *The Survival Book*, telling pilots how to get away with it under all conditions—desert, polar, jungle and water (just the thing to wear in your parachute pack). The same people have another of those Elsevier multilingual dictionaries—*Dictionary of Amplification, Modulation, Reception and Transmission* in Eng/Am/Du/Fr/It/Ger/Sp at £6. This includes a thumb index and you have to have your thumb indexed whether you like it or not. Which thumb is your index thumb?

A handout from the MIT (Massachusetts Inst. Technology) tells of ball-bearings with tolerances of 20 millionths of an inch. Perhaps we shall get a better ball-point pen now? The development results, it seems, from the needs of gyroscopes.

A new international quarterly comes from the Society for the History of Technology, Room 311, Main Building, Case Institute of Technology, Cleveland 6, Ohio, at $7 a year. It is called *Technology and Culture* and here's a cross-section of the stuff: "The Hardware of Culture" (apparently a few standard books on the history of technology). "Methods of Making Chain Mail (14th to 18th Centuries): A Metallographic Note"; "Sullivan's Skyscrapers as the Expression of Nineteenth Century Technology." The journal is well illustrated both on chain-mail and skyscrapers.

An attractive spring catalogue from Phoenix, the people who do books, pictures and kite-mark bookcases, has little in it to warrant mention here except for a book in their young people's section. It is *The Young Engineer* (Simplified Science and Engineering), by Charles B. Broschart at 12*s* 6*d*. It includes a chapter on "Engineering as a Career." One is told that there are 131 diagrams but, irritatingly, not how many pages. The address is 10-13 Bedford Street, and there's a distinguished street if you like.

Unusual in an engineering periodical is a paper "A study on investments" in the March *Memoires* of the Société des Ingenieurs Civils de France. "The ideas suggested to the reader are not meant for improving economics; they tend towards action: possible action, necessary action of the engineers to speed up the economic progress in France, by increased investments" (cribbed from the abstract).

A firm called Gille Associates Inc., at 956 Maccabees Building, Detroit 2, seem to have about 19 books on applications of punched cards. Each book is specialist to one application and if you want to know more write and tell them where you saw about it and they might think that their circular was not wasted. Sorry—22 books, one annual and a monthly magazine.

I am still waiting for chapter and verse on that tale of the American who laboriously did a cover-to-cover translation and then found that it was his own original bunged into Russian. A sort of red letter version.

Steam Power Station Atlas

Grosse Dampfkraftwerke: Planung, Ausführung und Bau. Edited by K. SCHRÖDER. Volume 1: Kraftwerksatlas. *Springer-Verlag, Heidelberger Platz 3, Wilmersdorf, Berlin.* (*DM* 192)

Volume 1 of this work on the planning, design and construction of large steam power stations is a massive compendium of 1,070 pages about actual plants, either existing or under construction, and is described as a "Power-Station Atlas." It confines itself to summarising the facts, the only comment being an analysis of the given data. The second volume, not treated in this review, will include more general chapters on modern power-plant practice, power station design and the selection of plant items.

The examples are drawn mainly from Western Germany and from the United States. A preliminary analysis is given of 200 stations, and there is a short description with drawings of 98 of these. A further eight recent ones have been added just before publication. Of the 200, 59 are from Germany and 90 from USA. Of the 98 plus 8 described, 34 are from the former country and 25 from the latter. Only seven are listed and six described from Great Britain. The remainder, from scattered locations over the world, appear to be of German design. Manufacturers' names are deliberately omitted.

There is a special section of 23 pages, which gives the appearance of a later interpolation to the main text, dealing solely with over 300 American stations. This appears to be extracted from the literature, that is, *Electrical World, Power*, and the statistics of the Federal Power Commission. All this will of course be readily available to English readers in the original.

To quote an example of the kind of comment made by the author: the proportion of once-through boilers in the mixed list of 200 (mainly German and American) is given as 48·9 per cent, whereas from the purely American list there are only 2·3 per cent of this type, but 23·2 per cent have assisted circulation. It would have been of more interest if the German stations had been analysed separately. The claim is made by the author, that power-station design is tending to become international, but the reviewer feels that there are still wide differences between current Continental practice on the one hand and British and American practice on the other. The averaging of the mixed data from the 200 stations might be misleading.

The next 570 pages contain the short descriptions of the selected 106 stations. Where full details are available this follows a standard pattern. There is a perspective drawing of the station, a site plan, the main piping diagram, the simplified electrical diagram, the ground plan and sectional elevation of the station. Scales are given and the drawings and diagrams are specially drawn and are very clear and easy to read. German symbolism is used but there is an adequate key. The stations are arranged systematically, beginning with the more advanced, Eddystone, Philo and Hüls, and ending with those of more moderate conditions and sizes.

The point is made that the book is intended to help those from newly developing countries, where the interest in the more advanced units is for the future. The drawings and diagrams occupy a good part of the six pages allotted to each station and the description is factual and gives only the leading features. It is difficult to see to whom this section of the book is addressed; maybe Volume 2 will explain how this mass of material is to be used. There is too little about each station. On the other hand, browsing through these careful drawings can have its fascination for the power-station enthusiast.

Only six British stations are thus described. In a two-page comment on Thorpe Marsh, the British 550 MW unit station, the author incorrectly states that there was a possibility of supercritical conditions for the first unit. This was never the case. The matter of the supercritical unit is, at the time of writing, still under review by the Central Electricity Generating Board, and in fact the second Thorpe Marsh 550 MW unit repeats the same subcritical conditions as the first.

The final section of the book, and easily the most valuable, devotes 420 pages to a detailed description of six widely differing stations, both in steam conditions and in size of unit. They are Eddystone and Galatin, USA, Fortuna and Emden, Germany, and San Nicolas and Cita da Roma, of the Argentine and Italy respectively. The size range is from 325 MW to 36 MW and the steam pressure from 5,000 to 520 lb per sq. in, with corresponding temperatures.

In these monographs, the reasons for the siting and the building of the stations are discussed, and the factors which determined the size and type of the units for that particular location. All the ancillary services are described, and the special features of the site and civil works are detailed. There are many clear photographs, diagrams and sectional drawings of the plant. Erection programmes are given and some overall costs.

This section is sufficiently detailed for readers to follow the complicated integration of all the structural and plant items which go to make the organic working unit, which is the modern power station. The author, who is the director of the power station department of Siemens-Schuckertwerke, has had the help of five of his colleagues in this latter section. They included Dr. Schmidt who helped with the supercritical Eddystone description.

The book sets out to look at power-station design as a whole and has this concept clearly in mind throughout. The mass of information in the first two sections of the book will no doubt be a useful reference source, and the author is congratulated on his painstaking thoroughness. The final section stands on its own merits and and will repay study. To those of us engaged in the business it is always fascinating to see how others solve similar problems to our own.

FRANK DRANSFIELD

Mass without Manoeuvre

The Great Wall of France: The Triumph of the Maginot Line. By VIVIAN ROWE. *Putnam.* (30*s*)

In 1919, when the First World War was won, France was in a bad way. She had been invaded twice within the memory of man; she had been bled white in the recent struggle; her birthrate was falling; America had withdrawn across the Atlantic; and Britain, in her usual way, was fraternising with the vanquished foe. France believed herself to be alone, and she distrusted the ability of the League of Nations to keep the peace. She feared above all things another war with Germany.

It is never easy to foresee the nature of the next war, as opinions are clouded by memories of the last. Only the most discerning recognised the writing on the wall. The Battle of Cambrai (1917) was the birth of the *Blitzkrieg*: tanks advancing in mass over suitable terrain, aeroplanes cooperating after a lightning bombardment; leadership from the front with radio to all; and the whole manoeuvre conceived in surprise to give the battle the sinister twist of the master magician. This was not all; Cambrai also revealed the spell to combat the magic; the firm base and the immediate counter attack.

The French had in the Maginot Line a firm

base and they should have had a " mass of manoeuvre " as well. But they had the balance wrong; they only had a mass incapable of manoeuvre. The magician had the top hat, but there was no rabbit inside it. It was an unpardonable miscalculation, aggravated by security measures that hid the defects till too late, and a propaganda that blinded the French to the need for active defence.

It is easy to see all this now, being wise after the event; and one feels as one reads Mr. Rowe's book, *The Great Wall of France*, that had André Maginot lived he might have got the balance right; for he was a man of imagination, courage and personality, beloved of the people, and effective in politics. But he died in 1932 and it was left to lesser men to plan the defence of France. The book shows us how Marshal Pétain, steeped in the past, unwittingly bedevilled the fortunes of France. It shows how the Maginot Line grew with one purpose only—to hold Alsace and Lorraine—yet how it came to be regarded as the shield for the whole of France.

The author traces the sequence of events up to the German attack on 10 May, 1940; and thence, day by day, till France fell.

It is a tragic story, fairly well known now, of " too little too late." A comparatively small force of German tanks, used in mass in the Cambrai style, cut the Allies in two. The British escaped through Dunkirk; Belgium and Holland collapsed; and the French, thrown piecemeal into half-planned battles, had no chance. Throughout all this the Maginot Line held, in spite of the attacks which the author assures us were genuinely determined. Your reviewer cannot express an instructed opinion on this assurance; though it is difficult to imagine the German war machine, grappling with the prodigious victories in the north, giving much thought to the south. They certainly gave no airborne troops—an obvious way to attack fortifications of the Maginot type.

Be that as it may, the Maginot forts were delivered up to the enemy after the armistice, not before it; and on that the author supports his sub-title, " The Triumph of the Maginot Line." Whether the reader will go so far with him is debatable; he will certain find an easily read account of an episode of peace and war that does very little credit to the elders of France between 1919 and 1940. And not much comfort is given to the British either.

MARK HENNIKER

Theory for Engine Mounting Practice

Vibration Engineering. By W. KER WILSON. *Charles Griffin.* (90*s*).

The author might have called this book the " Practical Solution of Engine Mounting Problems " as a companion volume to his well known treatise on torsional vibration. Three-quarters of the material of the book is in part two, which deals with vibration isolation, while part one, on torsional vibration and engine balancing, provides an adequate introduction on the assessment of engine vibration. The only variation on this theme is a section on the reciprocal problem of vehicle suspension systems, but this is only a short review and there is, for instance, no more than a qualitative discussion of the effects of damping.

Part one opens with a chapter on digital computers and is a timely reminder that much of the hard labour involved in the ensuing calculations may be avoided and that the designer no longer has an excuse for not examining all reasonable engine arrangements. No reference is made to the use of analogue computers in connection with part two, although there are many possible applications and damping terms can be included without inconvenience. The remaining chapters of part one cover the main aspects of torsional vibration (34 pages) and engine balancing (9 pages), but clearly these are not intended as a substitute for the many other works on these subjects and the reader is referred elsewhere for topics such as the theory of the slider crank chain the derivation of crankshaft stiffnesses, and the theory of equivalent rigidities and inertias.

The arrangement of the material in part two (chapters 9 to 17) is a little confusing. The fundamental property of a vibration isolation mounting is the transmissibility but this is not considered until chapter 15. Again, chapter 12 deals with the forced vibration of a body free in space but the significance of the results obtained would be much clearer if these were to follow those for a spring mounted body (chapter 13) as the limiting case at high frequency ratios. This aspect will not worry the vibration specialist, well acquainted with the standard theory, but the student might grasp the subject much better if the theory were separated from the practice.

Two chapters are concerned with frequency calculations and the details of mounting systems. There is a wealth of information here and no aspect of the practical problem is omitted. The full analysis of convergent mounting systems will be welcomed as well as the inclusion of gyroscopic forces in all computations where this is appropriate. Several tables give the characteristics of the principal types of commercial rubber mounts and the physical properties of typical rubbers. The author shows how a rubber spring can be designed but wisely suggests that static and dynamic calibrations of a prototype are desirable. The helical steel spring is the only alternative to the rubber spring for which design data is given, but the reader should be warned that some revision is required of the results in table 18 for the lateral stiffness of compression springs.

After the chapters on the forced and resonant vibrations of a spring-mounted body, the book ends with four chapters covering critical speed effects, vibration absorbers, the transmissibility of the engine-mount system and the effect of resilience in the foundations. Although the dynamic properties of rubber depend on frequency, the analysis always assumes that there is a spring element, with a constant dynamic modulus, with a viscous damper in parallel. This enables a first approximation to the performance of a rubber mounting to be obtained, but is this good enough in practice? The author has not dealt with this question and there is little introduction to the literature on this subject.

The menace of unwanted vibration and noise, which increases with the rising use of power, can only be countered by the isolation of vibration and improvements in the methods adopted, and the importance of the author's work in this field is recognised. But it is a little disappointing to find that in the final numerical example there is a vertical transmissibility of 60 per cent at the fundamental frequency of the engine, in the system considered. The superior performance of a low-frequency mounting is referred to in the book, and the use of a massive sub-base between a machine and the supporting springs, or of a non-linear spring system, is discussed and more practical information on these topics would be valuable in future editions of this book.

There are numerous worked examples throughout this treatise and all symbols and units are defined in each case. Considering the large amount of detail, there are very few typographical errors and only a few mistakes which the competent reader will soon detect. An adequate index is provided for the principal entries and there is a short bibliography, which is largely independent of the text, together with a selected list of British patents.

Putting theory into practice is never as easy as it looks, and the specialist in vibration engineering will welcome this book as a means of learning much from the experience of its distinguished author. The student who has studied vibration theory, and the specialist, will both find this a valuable reference book on engine mounting practice.

D. A. HARDING

Heavy Metallurgy

The Transuranium Elements. By GLENN T. SEABORG. *Yale University Press, New Haven;* and *Addison-Wesley Publishing Company, Reading, Mass. and London.* (53*s*)

Physical Metallurgy of Uranium. By A. N. HOLDEN. Prepared under contract with the United States Atomic Energy Commission. *Addison-Wesley Publishing Company, Reading, Mass. and London.* (44*s*)

Constitutional Diagrams of Uranium and Thorium Alloys. By FRANK A. ROUGH and ARTHUR A. BAUER. *Addison-Wesley Publishing Company, Reading, Mass., and London.* (74*s*)

Thorium Production Technology. By F. L. CUTHBERT. Prepared under contract with the United States Atomic Energy Commission. *Addison-Wesley Publishing Company, Reading, Mass., and London.* (44*s*)

Twelve volumes were sponsored by the United States Atomic Energy Commission for presentation at the Second Geneva Conference on the Peaceful Uses of Atomic Energy. These ranged from useful works of reference and monographs to rather more ephemeral descriptions of reactor systems but considerable care was taken in the selection of authors, each of whom is an expert in his particular subject.

The most illustrious of the authors is Professor Seaborg among whose many contributions to nuclear research are included the co-discovery of the nine transuranium elements known beyond dispute. The first part of his book gives an account of the discovery of plutonium, which includes not only the scientific aspects of the subject, but also an authoritative and entertaining history of the work and the men who carried it out.

The second part discusses the chemical properties of the actinide elements, and the properties of thorium are included so that the similarities and progressive changes of properties through the series can be clearly understood. The third part deals with the nuclear properties of the transuranium elements in a way which is both systematic and comprehensive. This is the first presentation of much of this information in its present form. In the last section Professor Seaborg indulges in prediction of elements and properties yet to be discovered and determined. Although he is becomingly modest, this part of the book is of great interest both as a guide to future investigators, and as an instructive lesson in scientific deduction. Professor Seaborg's book is of considerable interest both to the specialist who requires the information in a convenient form and to the general reader interested in scientific discovery, methods and techniques.

Continued on next page

The other three books which are considered here are all monographs designed for the specialist. The metallurgist concerned with uranium and its alloys will find two of the books almost indispensable.

Information on the physical and mechanical properties of uranium can be gleaned from many massive volumes and bulky collections of papers. Mr. Holden has compiled all those known up to the date of publication into one slim volume, and arranged them in a logical and readily comprehended order.

The book is perhaps most suitable as a text for nuclear metallurgy courses at an advanced level. Mr. Holden's skill and experience as a metallographer enables him to deal both with optical and X-ray crystallography with great competence. An engineer may find it very useful as a reference book even if he had no interest in the more advanced chapters. Not only are all aspects of the physical metallurgy of uranium covered but diffusion effects, radiation damage thermal cycling growth, and design of metallic fuel elements are covered in addition.

The standard compilation of constitutional diagrams is Hansen's *Constitution of Binary Alloys*. It costs twelve guineas and weighs 3 lb 15 oz. For the metallurgist interested mainly in uranium and thorium, Rough and Bauer's book has two obvious advantages: it costs 38*s* and weighs 1 lb.

In addition to the alloy systems dealt with in Hansen, Rough and Bauer include the important uranium-plutonium system and eight alloy systems of thorium including thorium-plutonium and thorium-beryllium. They also make slight corrections or additions of detail in nine further systems. In addition, Rough and Bauer treat 16 ternary systems of uranium and two of thorium which of course are not included in Hansen.

The only omissions of systems known to have been studied are the thorium-hydrogen system, three uranium ternaries (U-Zr-Mo, U-Nb-Mo, U-Mo-Cr) and two thorium ternaries (Th-Zr-U and ThC-UC-ZrC) reported by the Russians at Geneva. (The ThNa system reported in Hansen but not included in Rough and Bauer isnow known to be incorrect.) The book was written with the cooperation of representatives of the United Kingdom and the extensive references include material from both sides of the Atlantic.

The fourth book to be considered deals specifically with thorium, which has so far been the Cinderella of the nuclear metals. Because of its obvious potential in thermal breeder reactors much effort has been spent both in its extraction and on the investigation of its properties, but most of the thorium necessarily mined along with uranium is now dumped. Dr. Cuthbertson has performed a useful service in including practically all of the information on thorium production in one volume. This covers the subject more comprehensively than any previous publication, and includes material not previously available on an unclassified basis.

An account is given of the properties of thorium and its major compounds. Surprisingly some of the most recent determinations of physical properties are omitted in a chapter which otherwise follows faithfully accounts in earlier books. The detailed information suffers from the difficulty of producing thorium in its pure state, since the addition of oxygen modifies the properties appreciably, and the many investigators have produced differing results depending on composition.

A very complete account of the methods of concentration and purification of thorium ores follows, and is succeeded by a description and discussion of the methods so far used to produce the metal. In general the most successful methods have been the reduction of mixed halides of zinc and thorium to produce an alloy from which the zinc can later be distilled, and the reduction of thorium dioxide to powder by calcium. Dr. Cuthbertson has omitted to mention the work carried out in England on this latter process. Further chapters treat melting, fabrication methods and testing procedures.

The book is mainly concerned with processes developed in the United States but the references include English work.

L. M. WYATT

New Books

Lectures on the Theory of Functions of Real Variables. By JAMES PIERPONT. 2 volumes. *Dover Publications, New York; Constable, London.* (40*s*)

Reprinted from the original editions of 1905 and 1912 respectively, these two volumes are "based on lectures which the author is accustomed to give at Yale University." One of a series of mathematical classics reprinted in paperback form.

The Institution of Mechanical Engineers: Proceedings of the Automobile Division, 1956-57. *The Institution, 1 Birdcage Walk, Westminster, London, SW1.* (Members 20*s*; non-members 41*s*)

Now in permanent form are papers on rubber springs for vehicle suspension, hydrokinetic fluid drives, transmission developments, gaskets, gudgeon pins, superchargers and supercharging, and automobile stability and control.

Lloyd's Register of Shipping, Register Book 1959-60. Volume 4: Directory. *Lloyd's Register of Shipping, 71 Fenchurch Street, London, EC3.* (60*s*)

Contains lists of shipbuilders with existing ships they have built; marine engine builders; dry and wet docks; telegraphic addresses and codes used by shipping firms; and marine insurance companies.

A Century of Traction Engines. By W. J. HUGHES. *Percival Marshall.* (30*s*)

It is clear that this heavily illustrated account of the rise and decline of the traction engine will be an invaluable source book for both the historian and the modeller. An outline bibliography is given.

British Shipping. 2nd edition. By R. H. THORNTON. *Cambridge University Press.* (21*s*)

The 20 years that have elapsed since the first edition of this survey of a vital industry have necessitated complete rewriting. Following a history from the coming of steam, the present working of the industry, the different types of ship and the men who sail them are described.

Electrical Safety. By H. W. SWANN. *Macdonald and Co (Publishers).* (40*s*)

The author, formerly H.M. Senior Electrical Inspector of Factories, has taken the Factory Electricity Regulations as his theme, and illustrated their application in industry and, as an appendix, in the home.

Ultimate Particles of Matter. By D. T. LEWIS. *Chantry Publications Limited, 63 Neal Street, Shaftesbury Avenue, London, WC2.* (15*s*)

A popular introduction to nuclear science for the layman illustrated by diagrams, doggerel verse, and a story entitled "Alpha in Nuclearland." Previously published by AWRE News, Aldermaston.

String Figures and Other Monographs. *Chelsea Publishing Co., 50 E. Fordham Road, NY 68, NY.* ($3·95)

A collection of four facsimiles reprints, of W. W. Rouse Ball on string figures, Julius Petersen on geometrical constructions, H. S. Carslaw on non-Euclidean plane geometry and trigonometry, and Florian Cajori on the history of the logarithmic slide rule.

Advanced Structural Design. By CYRIL S. BENSON. *Batsford.* (50*s*)

Although suitable for the Associate Membership examination of the Institution of Structural Engineers, this is a practical book equally intended for working engineers, architects and surveyors. The 17 chapters each deal with a particular functional structure or type of structure.

The Reviewers

Mr. Frank Dransfield, B.Sc. (Eng.), M.I.Mech.E., A.M.I.E.E., M.I.Fuel, is boiler plant design engineer in the Power Plant Design Branch of the Central Electricity Generating Board. He has previously worked with the Yorks Power Company, Leicester Corporation and Babcock and Wilcox Limited.

Brigadier Sir Mark Henniker, Bart, C.B.E., D.S.O., M.C., was commissioned into the Royal Engineers in 1926 and served as a Regular Army Officer for 32 years. When he retired from the Army he became Honorary Colonel, a Parachute Engineer Regiment of the Territorial Army, and now works in a firm of ship repairers.

Mr. D. A. Harding, M.A., B.Sc., A.C.G.I., is a research engineer in the British Hydromechanics Research Association. After serving in the research department of Stewarts and Lloyds, he joined the scientific staff of the National Physical Laboratory, where he was concerned during the war with problems on the initial yawing oscillations of a spinning shell, and later with mechanical vibration studies, including the transmissibility of antivibration mounts and the design of very low frequency mounts for the isolation of scientific instruments. He also played a leading part in measuring the structural damping of the concrete chimney at the Ferrybridge "B" power station and the Crystal Palace television tower.

Mr. L. M. Wyatt is chief metallurgist of the Central Electricity Generating Board and a fellow of the Institute of Metals. He was formerly a technical manager in the Industrial Group of the United Kingdom Atomic Energy Authority.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted

Tools

Files. ENGLISH STEEL CORPORATION LTD., River Don Works, Sheffield 9. The "Cyclops" range of files and rasps. Forty types listed, both hand and machine; sizes from 3 in to 20 in. Booklet.

Lathes. KERRY GROUP MANUFACTURING DIVISION, Warton Road, London, E15. Broadbent 18 in and 22 in swing lathes. Take 48 in between centres; three speed ranges covering 10 to 1,000 r.p.m. Leaflet.

Drop Hammer Control. B. & S. MASSEY LTD., Openshaw, Manchester 11. The Aeromatic system of drop hammer control for light or heavy blows Leaflet gives description.

Boring Tools. MACHINE SHOP EQUIPMENT LTD., Spenser Street, London, SW1. Cartridge tools for boring and turning with micrometer adjustment set by Allen key. Various types and sizes. Catalogue.

Handled Tools. J. STEAD & CO. LTD., Manor Works, Sheffield 2. Screwdrivers, chisels, padsaws, etc., with unbreakable amber plastic handles; also pliers, hacksaw blade and tool kits. Illustrated catalogue.

Machine Equipment. C. M. G. CALVER LTD., High Street, Bushey, Herts. "Revlac" chucks, indexing tables, and machine vices. List and leaflet.

Non-Cylindrical Turning. THOMAS CHATWIN & CO. LTD., Great Tindal Street, Birmingham 16. The Chatwin Polygon tool box for fitting to lathes for turning hexagon, octagon, square, and other shapes. Full description and methods of use in a 40 page brochure.

Heavy Duty Lathes. DENHAMS ENGINEERING CO. LTD., Empire Works, Holmfield, Halifax. Centre lathes from 17 to 42 in swing, also surface and boring lathes; fifteen models. Illustrated catalogue.

Hydraulic Presses. JOHN SHAW & SONS (SALFORD) LTD., Wellington Works, St. Stephen Street, Salford 3. Hydraulic presses for flanging, bending, baling, dewatering, trimming, powder metallurgy, embossing, etc. Up to 3,500 tons. Also hydraulic accumulators and control valves. Catalogue No. 59.

Spanners and Wrenches. CONDRUP LTD., 67-73 Worship Street, London, EC2. The Bahco range of adjustable spanners, plain and torque wrenches and screwdrivers. A 16 page catalogue.

Marketing

Hardboard in South Carolina

THE first hardboard mill in the Eastern United States, the BOWATER BOARD Company's $7 million new plant at Catawba, South Carolina, is to go into production in June.

A further step in Bowater's North American diversification schemes, the mill can turn out 160 million sq. ft of $\frac{1}{8}$ in hardboard a year. Much of the United States furniture industry is established in the Carolina States and in the early years of the mill its production is expected to be absorbed in an increasing use of hardboard by the furniture trade.

House building and the light construction industries are expected to come in as major customers later.

Electrodialysis and Ion Exchange Tie-up

G. & J. WEIR, the water treatment engineers, have become the only company in Europe covering every aspect of water treatment. Their recent purchase of the COUNTY WATER SOFTENER Company, of Surrey, brings into the group an organisation which has recently made some important advances in water treatment by using ion exchange resins.

The value of the move to the Weir Group lies in the broader coverage, taken with their own work in evaporation and electrodialysis methods, which will be applied over the whole field.

Argonauts End a Fine Record

When Argonaut Aurora (BOAC airliner G-ALHG) landed at London Airport on the second Friday of this month there ended a chapter in the history of the Corporation.

From their introduction back in 1949, the Argonauts, cumbrous looking monuments to a more spacious age in air travel, flew 106 million miles for the Corporation, which had 22 of them, and carried 870,000 passengers.

Powered by Rolls-Royce engines the solidly shaped Argonauts had served on almost every BOAC route except the North Atlantic. Nine of the fleet have been sold to OVERSEAS AVIATION Limited, four to the Royal Rhodesian Air Force, three to the EAST AFRICAN AIRWAYS CORPORATION and three to ADEN AIRWAYS. BOAC is keeping one for apprentice training.

The last Argonaut service is being replaced by a Britannia flight. The jet-prop Britannia makes this particular trip, to Abadan with stops at Beirut and Damascus, three hours quicker than the Argonaut.

BOAC Services through Cairo Resumed

After three and a half years of suspension BOAC has now resumed its services through Cairo. Comet 4's will operate four return flights a week between London and ports in Pakistan, India and the Far East.

In effect, Cairo is now nearer London, by air, than before the Suez incident. The Comet 4's do the journey in six and a half hours. Three of the services leaving London each week end in Hong Kong, the fourth in Bombay.

Getting all Lit up at the Double

A combination of rapid ordering methods and versatile manufacturing facilities has made it possible for SIEMENS EDISWAN Kuwait fluorescent lanterns to be delivered to Salisbury, Rhodesia, in time for the advance arrangements for the Queen Mother's visit there next month.

The local authority's problem was the illumination of the long boulevard with its central island of palms and jacaranda trees down which the Queen Mother will drive from the airport. From the decision at the end of January to order the Siemens Ediswan Kuwait lantern the time for its manufacture and delivery was only as far ahead as the first days of this month.

ASSOCIATED ELECTRICAL INDUSTRIES EXPORT was informed in London, and instructions given to the AEI works at Spennymoor, Co. Durham. It is at this point that the advantages of the manufacturing system become essential. The Kuwait unitary system of parts makes it possible to produce 150 types of lantern from the specified code numbers. Large stocks and ranges of assembled lanterns do not have to be carried.

While the lanterns were being assembled at Spennymoor, space was booked on the BLUE STAR LINE ship "Auckland Star" which makes the Cape run in 15 days against the three weeks taken by many other cargo vessels. From Cape Town the lanterns went up to Salisbury by rail.

More and More Fordsons

With only slight increase in the speed of its production lines the FORD TRACTOR Division would be producing exactly one tractor for each day of the year in every single working day.

In fact the daily output figure is 356, the highest ever achieved at Dagenham. The first quarter's production of tractors was 20 per cent higher than the first quarter of 1959. While to the already highly mechanised British home market Ford were able to raise their first quarter's sales by 2·6 per cent; abroad, where the dealers can in some places sell all they can get, sales rose by 35·4 per cent.

The greatest percentage increases in foreign markets were 139 per cent more sold in Australia, 134 per cent in New Zealand and 103 per cent in South Africa.

Sales to the tough United States market, where Fordsons are in competition with home-bred Ford, were pushed up by 20 per cent, 5 per cent less than the average increase in sales to European buyers.

21 Ships for Same Line in 22 Years

Three cargo liners, of 12,160 tons each, have been ordered from the Sunderland shipbuilding firm, WILLIAM DOXFORD AND SONS. The order is worth some £2,500,000.

Two of the ships will be completed this year and the third in 1961. They are for the BANK LINE, of London, for whom Doxford have made 21 motor ships in the last 22 years. The Bank Line is managed by ANDREW WEIR SHIPPING AND TRADING.

Three Camera Team at Chicago Show

Three new television cameras, produced by ELECTRIC AND MUSICAL INDUSTRIES ELECTRONICS Limited have been on show at the National Association of Broadcasters' exhibition in Chicago.

Negotiations are going on for the sale of ten of the colour cameras shown, worth £20,000 each. The EMI colour camera concerned is cheaper and easier to use than conventional colour cameras. It uses three vidicon tubes and has a new optical system which is claimed by EMI to be several times more efficient than relay lens systems. The lightness and small size of the camera are particularly helpful to studio people who want to gain experience of colour work.

One camera has already been sent off to Peking for use in a hospital and another has been ordered by the Ministry of Aviation.

EMI was also showing its CPS/Image Orthicon camera which is able to use two sizes of Image Orthicon or a CPS Emitron pick-up tube. The camera has already been ordered for use in the United States, Canada, Australia and Hungary.

The third camera in the EMI exhibition team was a newly designed vidicon camera which uses printed circuits and plug-in techniques. This unit, which has all the normal facilities, costs only half as much as cameras with different tubes. It is used by the BBC in a number of interviewing studios and has also been ordered abroad.

Plessey Electric Systems on Vickers VC10

The electrical generating system of the Vickers VC10 jet airliner is to be by PLESSEY. A £700,000 contract for the job has been given by Vickers.

The contract follows Plessey's licensing agreement reached with the United States WESTINGHOUSE CORPORATION which permits Plessey to manufacture and market Westinghouse aircraft electrical generating systems. This right applies throughout the world except the United States and Canada.

The power requirements of a modern passenger airliner are highly diverse. They vary from the main flying controls and the navigational equipment to kitchen equipment and the ubiquitous electric razor.

One VC10 has a power output that could supply a village of 300 houses with both power and light.

Data Processing— a Many Purpose Thing

The department of real estate of New York city has found a novel, if not particularly pleasing, application for an INTERNATIONAL BUSINESS MACHINES data processing apparatus. It has installed an IBM 403 which gives an immediate check on all the city's tenants in arrears with the rent. The former manual check allowed the arrears to pile up for two months before they were detected.

The immense IBM Stretch which is being installed for the United States Atomic Energy Authority has a capacity equal to the coordinated work of more than half a million arithmeticians. Unlike the arithmaticians it can work three shifts a day.

What is not clear is how the work potential of half a million arithmeticians came to be known, unless a computer was used.

Tea Break Timer in Improved Form

Astutely enough the ELECTRICAL REMOTE CONTROL Company welcome the introduction to industry of the 42-hour week by introducing their Mk 2 automatic tea break timer type TBT.

The automatic tea break timer has a standard timing period of ten minutes though settings of 15, 20, 30 and even 60 minutes can be provided. Once the start push button has been pressed this electrically operated and impartial superviser goes into action and, at the end of the break, triggers off the appropriate bells or hooters.

In a shorter working week the tea break will certainly be closely watched and kept within bounds. At the same time with automatic sales machine dispensing tea, coffee and light snacks there will be places where the tea break will vanish altogether, continuous production being accompanied by continuous refreshment.

American Interest in Italian Steel Company

Among the literature produced by the United States steel industry it is not difficult to find pictures of foreign steel being carried into USA ports. With these in mind it is not so easy to be sure in which direction the UNITED STATES STEEL CORPORATION was looking when, as recently reported on the Continent, it considered the possibilities of taking a substantial holding in the highly modernised Cornigliano steel plant of the state-owned FINSIDER group.

It would be the automatic reflex of recent thinking to assume that the American company was looking for a foothold in the growing European Common Market. But, in the not over likely event of such an association coming about, some benefit from the price advantage of European steel would go to the United States holding.

For the long term, the fascinating question arises as to whether American companies for the reasons given here, might not at some future date be seeking financial interests in the European Free Trade Area, and therefore in British steel companies.

Price Manipulations by Polish Government

Price reductions in Poland are a matter of direct Government decree rather than exhortation.

The Polish administration at the beginning of the month cut the prices of wrist watches, radio and television valves and a number of items of food by up to 40 per cent. At the same time the prices of some electrical equipment, of screws, nails and certain chemicals were increased.

The value of the price cuts was three times that of the increases.

Heat Exchanger of Cheap Materials

A heat exchanger element for very high temperatures, which may be manufactured from cheap heat-resisting alloys, has been designed in Czechoslovakia by engineers Jiří Schneller and Bohumil Pokorný.

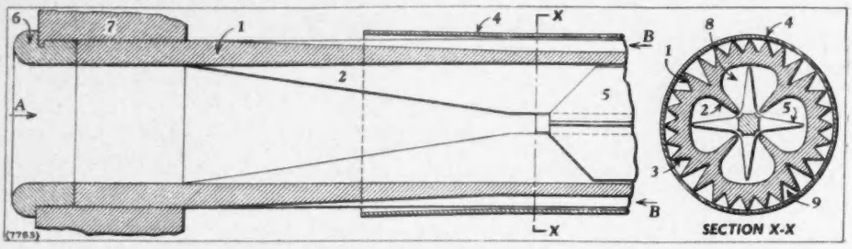
The body of the element is a profiled tube, the primary wall (1) of which forms four symmetrical arches which, at the point of contact on the inner surface of the wall, extend as protruding longitudinal webs (2). These webs increase the inner heat transfer surface and divide the interior of the body of the element into four interconnecting channels (8). On the outer surface of the primary wall a number of longitudinal fins (3) increase the external heat transfer surface of the body.

The body is inserted into a cylindrical jacket (4) of a slightly larger inside diameter than the circumference established by the rounded crests of the longitudinal fins, and a number of channels (9) are formed between these fins. To achieve a uniform thermal loading of the wall, the fins are shaped in such a manner that, with the wall thickness along the circumference being practically unchanged, the channels remain substantially the same in cross-sectional area. Therefore, at points on the wall corresponding to the webs the depth of channel is increased (the pitch being reduced accordingly).

The webs and fins serve, also, as a reinforcement of the body of the element, which may thus withstand high pressure differences. Hot exhaust gases may flow along the inner channels of the element (arrow A,) and clean air under pressure along the outer channels, in countercurrent (arrows B). To increase the heat transfer from the inner parts of the element to the periphery, a radiation element (5) may be further inserted into the central space. This element is star shaped, its arm extending into the inner flow channels.

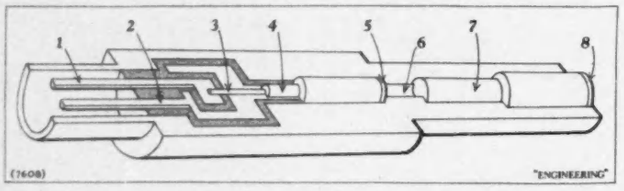
The area of high temperatures lies at the exhaust gas inlet A, and the ceramic ring (6) is inserted into the tube plate (7) to protect the edge of the cast body. In order to reduce the thermal stresses in the cast body, and at the same time to facilitate the mounting of the element in the tube plate, the wall is designed so that near its ends the outside fins and inside webs merge to form a smooth thick-walled tube. The height of the webs decreases towards the end of the tube more rapidly than the height of the fins, in order to increase the area ratio of outer to inner heat transfer surface in the direction of the exhaust gas inlet.

The element has been developed to withstand temperatures up tc 1,000° C and pressure differences between working fluids of up to 10 atmospheres. As stated, it does not call for the use of rare or expensive alloys.



Only cheaper materials are used in this high temperature heat exchanger.

Electric Detonator Resistant to Friction, Impact and Fire



This low-energy detonator possesses a high degree of inherent safety. It is very compact and is intended for use in missiles and rockets.

An electric detonator that uses no primary explosives, and yet will detonate on the current needed to light a standard flashlight bulb for 1/50 sec, has been designed and tested by the Armour Research Foundation of Illinois Institute of Technology in Chicago.

The device, developed for Picatinny Arsenal of the US Army Ordnance Corps, was conceived in an attempt to simplify and lighten the complex and often hazardous fusing systems now used in the Army's missiles and rockets. Still in the early stages of development in ARF's explosives research section, it has already indicated that " chains " of unstable but readily detonated primary explosives may no longer be a requirement for practical low-energy detonation.

Although the detonator may eventually be used for a variety of military and civilian purposes, it was specifically designed for use with auxiliary explosive devices in the Army's missiles and rockets. Such things as self-destruction systems, explosive bolts, stage separation mechanisms and explosive actuators, all at the moment employ either the primary explosive detonators or exploding wire devices requiring millions of watts for reliable functioning.

Both these systems are frequently impractical. Detonators containing primary explosives, often used without safety or arming mechanisms, add considerably to the hazards of handling missiles, and the exploding wire systems demand power sources of prohibitive size under the stringent space and weight limitations of space-age weapons.

This low-energy detonator is based on the principle that a high explosive, while extremely difficult to explode, is relatively easy to burn and that a burning explosive, if properly manipulated, can be made to detonate. Electrodes (1) and (2) are insulated, and a minute current flows through a thin column of high explosive mixed with a special carbon (3) and ignites it. The burning is amplified down the column (4), and builds up enough pressure to rupture a brass disk (5). Fragments of the disk leap an air space (6) and cause detonation in another column of high explosive (7). This explosion ruptures the rear wall of the device (8) and detonates the main charge.

An unusually high degree of safety is inherent in the device. By using only high explosives, the detonator becomes as impervious as the main charge to friction, impact and fire. It is also immune to spurious electrical currents, since the charge, no matter how powerful, must be channelled through a specific point of the explosive to achieve combustion.

The device, however, is extremely easy to detonate with the proper current. Test models have been developed which operate on as little as 200,000 ergs, which is quite small when it is remembered that it takes 10 million ergs per sec to make one watt. Later models will probably function on less than a quarter of that energy.

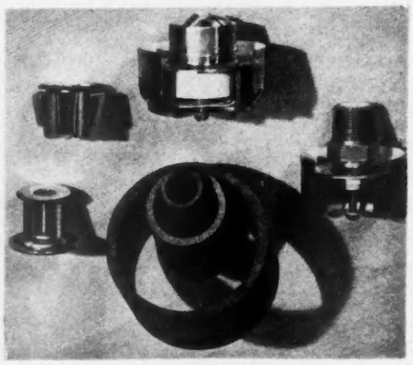
Ribbon Filter Elements

Tecalemit Limited, of Plymouth, are producing new ribbon filter elements for the efficient and rapid filtration of air, water, petrol, oil or other liquids, where the particle to be removed is in the order of 40 microns. The element consists of a ribbon of resin-impregnated creped material helically wound edgewise on a rotating mandrel and electrically polymerised and fused to form a hollow, open ended cylinder. The corrugations of the ribbon form numerous passages between adjacent turns of the helix, through which the fluid can flow freely while the foreign matter is retained on the ribbon edges, inside or outside the cylinder according to the direction of flow.

In addition to the qualities mentioned above these elements have another feature, in that they are easily cleaned for further use by washing in petrol or paraffin, or by blowing through with an air line. When conditions allow, a reversed flow of clean fluid or compressed air can be passed through the element, forcing the particles away from the ribbon edges and out through the drain valve.

Elements will be available in sizes varying in outside diameter between $\frac{3}{8}$ in to 6 in and having a wall thickness which varies from $\frac{3}{32}$ in to $\frac{1}{4}$ in respectively.

These new elements can be supplied incorporated in a range of air breather filters for crankcases, gear and axle housings, vacuum and air brake systems, hydraulic reservoirs, pneumatic cylinders, etc.



Ribbon filter elements and air breather assemblies.

Epoxy Resins for Making Electric Cable Joints

The development in recent years of epoxy casting resins has permitted a different approach to the design of electrical equipment. While initially used for the protection of insulation of electronic components, they have now been widely adopted in power frequency equipment. In conjunction with suitable fillers, they have been used in the insulation of current transformers, surge arrestors, bushings and switchgear, both at distribution voltage and at transmission voltages up to 150 kV. As a fairly recent innovation, small castings have been used in the design of oil-filled cable accessories up to 132 kV.

The properties of epoxy resin and filler casting material, and in particular its excellent electrical characteristics, make it most suitable for power cable joint construction. To take advantage of the material's remarkable toughness, adhesion to other materials, resistance to heat, water and chemicals, and low shrinkage, a radical departure from conventional jointing technique is required which in turn greatly simplifies the whole operation.

Briefly, the method is to form a mould around the jointed, but bare, conductors, into which the epoxy compound is poured at ambient temperature. The compound is self-curing and forms a solid casting. The cast serves as an electrical insulator, provides mechanical support and strength, and because of its adhesion to the metals and insulating materials used in the cable construction, results in a solid waterproof enclosure. No hand application of insulation to the conductor is required and the usual protection of a cast iron box can be dispensed with in many situations.

Results of laboratory work to date indicate that epoxy resin joints are likely to have many advantages for paper insulated cables, but their use might be more rapidly adopted for pvc insulated power cables, for which there is a growing demand particularly among the oil companies.

When used with paper insulated cables, an epoxy resin joint has a particular advantage over the conventional joint construction employing semi-fluid compound, for those conditions where, in the past, migration of compound has occurred leading to collapse of the sleeve and joint failure. Further, the casting presents a complete barrier to the movement of cable impregnating compound across the joint.

For pvc insulated cables, probably the most outstanding advantage is that the cast is made at ambient temperature. During curing the compound creates its own heat, but even with the largest joints the temperature reached does not exceed 60° C. Once the material has cured, it does not flow under the application of normal heat and pressure and thus is non-migrating during service.

The method of construction used by Johnson and Phillips Limited, Charlton, London, SE7, is as follows: after jointing the conductors by soldering, clamping or compression, the cores are maintained in the correct position by spreaders. With unarmoured lead or aluminium sheathed paper insulated cables the mould is formed by the normal lead sleeve plumbed to the sheath, and the protection of the usual iron box is not required. With armoured paper or plastic insulated cables, the iron box is used as the mould in order to provide electrical continuity for the armour.

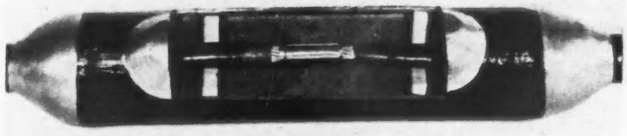
After constructing the mould, the resin and filler are mixed at ambient temperature with an appropriate hardener, poured into the mould, and allowed to set.

Joints to the above designs made on three core 11 kV paper insulated cable and on three core 660 volt pvc insulated cable have been subjected to thorough proving tests. They have been found to possess an electrical strength under alternating voltage and surge conditions not less than that of the cable. Furthermore, the electrical strength is unaffected by extended load cycle tests. From the mechanical viewpoint, no water penetration of the cast in the pvc insulated cable has been observed under a hydraulic pressure of 50 lb per sq. in and no loss of electrical strength was found to arise from this exposure. The action of the cast as a compound barrier when applied to paper insulated cables was such that no passage of compound occurred across the joint under a pressure of 100 lb per sq. in during extended temperature cycle tests.

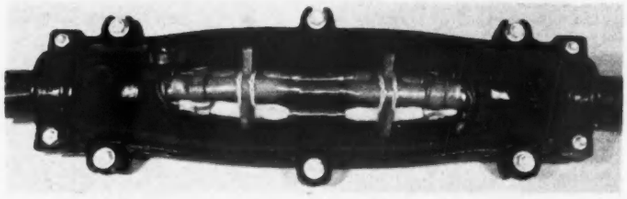
Experience has shown that there is no difficulty in making the joints, and on technical grounds they have many advantages—particularly for use with pvc power cables and for special applications with paper insulated cables such as where compound migration is a hazard. Coupled with mechanical jointing of the conductors epoxy resin permits jointing without the application of heat, with its obvious advantage under fire or explosion hazard conditions.

The position of costs is not so clear cut. Epoxy resins are expensive, although it is probable that with expanding use the price will come down. On the other hand, the time taken to make a joint is reduced.

Joints have now been in use for about two years on an experimental and commercial basis.



(Right) A half-filled joint on a three core paper insulated cable.



(Left) Joint in a three core 660 V pvc-insulated and pvc-sheathed cable shown prior to pouring in the epoxy resin.

Constant Speed Alternators for Aircraft

Following a licence agreement with Precision Méchanique Labinal in Paris, the Plessey Company are now starting to manufacture a range of aircraft constant speed alternators. The 4 kVA unit in this range is designed to operate at altitudes of up to 55,000 ft with forced draught cooling and will withstand accelerations up to 15 *g* in all directions. It has been operating successfully in French fighter aircraft for some years and a French type approval has been obtained.

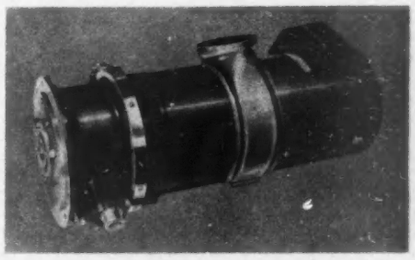
At the moment machines have been developed over the power range 4 to 19 kVA and units of up to 35 kVA are currently being investigated.

The machines embody the Labamatic principle of constant frequency control, which is based on an electromagnetic coupling incorporated in the drive to the alternator shaft. Constant rotor speed is maintained by controlling coupling slip by means of an amplifier system and a frequency sensitive network. The electro-magnetic coupling may be employed in conjunction with a variety of gear drive arrangements and these are essentially of a simple nature. In order to improve efficiency an automatic two-speed gearbox is in some cases included in the drive. With this addition an engine speed range of $3\frac{1}{2}:1$ may be obtained.

The simplicity and flexibility of the Labamatic system lends itself to a rapid introduction of new machines specially tailored to suit particular installation requirements.

The first machine to go into production is a 4 kVA, 208 V, 400 c/s unit, shown in the illustration, having a unity to 0·75 lagging power factor. When this alternator is coupled to a drive ranging from 2,900 to 8,000 r.p.m., the output voltage is maintained constant to within ± 2·5 per cent and the frequency to within ± 2 per cent. Overspeed is permitted up to 9,000 r.p.m. for short periods. An electrically-operated automatic 2-speed gearbox is fitted as standard equipment on the 4 kVA model. Magnetic amplifier circuits are used throughout the control system and protection is provided against undervoltage, overvoltage, underfrequency and earth faults.

The total weight of the machine, together with frequency regulator, voltage regulator and protection unit, is 72 lb. In an alternative form without automatic 2-speed gearbox, the machine is suitable for drive shaft speeds of from 4,700 to 8,000 r.p.m. and the total weight is then reduced to 64 lb.



The 4 kVA alternator maintains constant frequency to within 2 per cent for drive speeds from 2,900 to 8,000 r.p.m.

High Compression Barriers

The noises of abnormal combustion in engines indicate a barrier to higher compression ratios.

As most drivers know from experience, many noises can make themselves heard in a car. Most parts make their own special acoustic contribution, but combustion in the cylinders appears to do so with the greatest versatility.

In recent years interest in the phenomena producing the sounds has increased. This largely arises from the pursuit of higher compression ratios. Theoretical ratios of 17 : 1 are feasible and would produce greater fuel economy and engine power—were it not for the abnormal combustion phenomena that accompany high compression (over 10 : 1, say). Such phenomena are power consuming.

Already, knock is becoming more frequent than it used to be. Although knock used to be associated with full throttle operation, it now appears in high compression engines at part-throttle conditions. This is largely due to changes in spark timing. For full throttle operation of an engine, a retarded spark is normally used instead of maximum-power spark advance, for good reason: most engines produce more power at full throttle with the same fuel and constant incidence of knock if the compression ratio is raised above that for knock at maximum power and the spark is retarded to reduce the knock level to the baseline value. But this leads to a spark that is too greatly retarded at part-throttle for maximum economy. Therefore a vacuum-controlled spark advance mechanism is installed to advance the spark at part throttle. Then, however, knock may be noticed at part throttle, particularly at low speeds where the charge density is high, and especially with the more sensitive fuels. Some engines knock over a wide range of throttle openings and may even knock more at part throttle.

AUTO-IGNITION

L. S. Echols, V. E. Yust, and J. L. Bame, of Shell Oil Company, have recently put forward a theory relevant to the practical problems of knock, hot-starting noise, silent knock, pre-ignition-induced knock, knock-induced pre-ignition, and engine roughness. They suggest that, in the absence of catalytic effects, all these phenomena are related to the ignition delay characteristics of the fuel, and that the controlling factor in knock is auto-ignition. Oxidation processes occur ahead of the flame front in a way that appears to sensitise the unburnt gas, so that after a short delay it burns throughout its volume. The theory put forward suggests that as gas temperature is raised, the rate of heat release from the oxidation reaction is initially too low to produce a gas temperature higher than the cylinder wall temperature. But a point is reached when the heat release rate exceeds the heat absorption rate—this is the spontaneous ignition temperature of the gas mixture in the particular circumstances.

R. F. Stebar, W. M. Wiese and R. L. Everett, General Motors Research Laboratories, pick out rumble as a noise that must be eliminated before compression ratios can be raised. It sounds like loose connecting rod bearings. By frequency analysis and strain gauge methods, the authors have identified it as resonant engine vibrations between 500 and 1,600 c/s. It is directly related to the presence of combustion chamber deposits which, when hot, initiate several flame fronts. Losses up to 13 per cent have been observed during a rumble cycle, the lost work being in the form of heat rejected to the cylinder walls—causing over-heating.

Fuels can be separated with respect to rumble resistance. Leaded iso-octane has a high rumble resistance and leaded benzene a low one. Commercial fuels, however, show very little variation in this respect at present. The more volatile lubricating oils can encourage rumble.

In their experiments with a 1958 V-8 engine, E. S. Starkman (University of California) and W. E. Sytz (California Research Corporation) have identified knock as vibrations in the frequency range 5,000 to 8,000 c/s and rumble as extending from 600 to 2,000 c/s. Their experiments were carried out at a compression ratio of 11 : 1. From strain gauge measurements they concluded that rumble is connected with a bending vibration of the crankshaft due to high rates of combustion pressure rise near top dead centre. They identify thud as a component associated with torsional vibration of the crankshaft due to high rates of pressure rise earlier in the stroke. Thud can sometimes be eliminated by replacing the plugs by others of a lower heat range.

Records of cylinder pressure and the accompanying noises obtained by A. E. Felt, J. A. Warren and C. A. Hall are shown in the diagram.

L. Gross-Gronomski, Israel Technological Institute, has been carrying out experiments on the use of precombustion chambers to eliminate knock. In spark-ignition engines, knock reduction can be achieved by reducing the spark advance angle below the standard value. Unfortunately, this lowers the engine power and causes overheating of the exhaust valves and plug electrodes. By use of a precombustion chamber around the sparking plug, it is possible to alter the timing without such ill effects. Experimental chambers have been successful in reducing knock, but a loss of power and efficiency was noted with rich mixtures.

A survey of chemical methods of reducing knock and rumble was given by W. G. Lovell, Ethyl Corporation, during his delivery of the James Clayton Lecture at the Institution of Mechanical Engineers. The number of hydrocarbons suitable for use in high compression engines is quite low. Paraffins with the same chemical formula, but different structure, can vary greatly in their resistance to knock. For example, normal heptane and triptane are both heptanes and have the same number and type of constituent atoms; but normal heptane knocks so badly that it is unsuitable for any engine, while triptane is so free from knock that it has been operated at compression ratios of 15 to 1. Unfortunately, there is no convenient commercial process available for reorganising the simple chain of atoms in normal heptane into the branched chain of triptane. Saturated petrols with an octane number over 100 will, however, require such " tailormade " molecules. A somewhat similar situation exists for napthenic and unsaturated hydrocarbons as gasoline components.

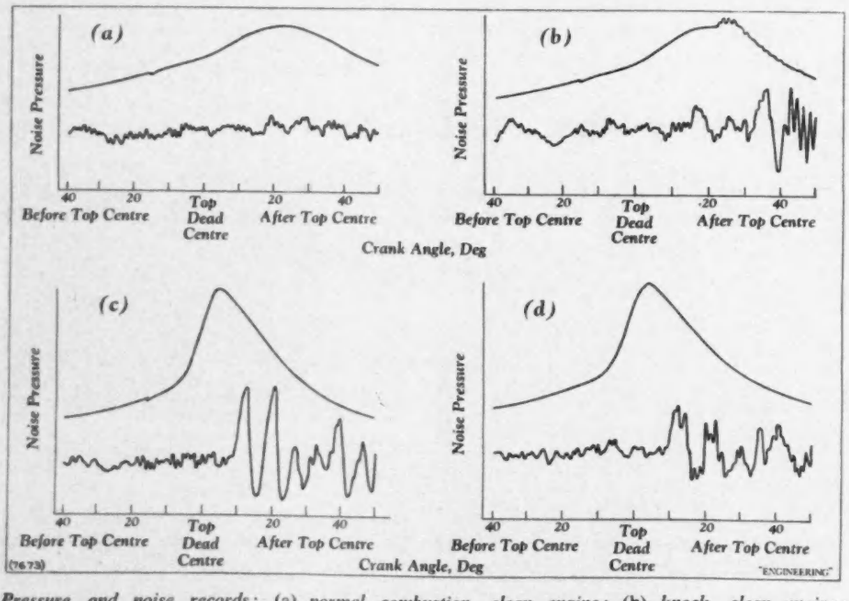
BOOSTING LEAD ADDITIVES

Almost all the aromatic hydrocarbons are suitable for high-octane fuels, as far as octane number is concerned. But many have serious disadvantages—volatility limitations, production of detrimental deposits and low response to anti-knock additives. " Refining processes," concludes Mr. Lovell, " will have to be changed to produce the kind of molecule we need."

Metallic anti-knock additives are a further method of raising fuel octane number. In the United States, base gasoline has increased about 10 octane numbers over 10 years, due to changes in refining practice. A similar gain in octane number can be achieved by adding lead to the extent of 3 ml per gallon of fuel. In fact, the present difference between " regular " gasoline of 92 octane and " premium " of 99 octane is about equivalent to 3 ml of tetraethyl lead.

Recently, new metallic additives based on manganese have become available. They have the property of boosting the effect of lead additives. A few per cent of manganese added to lead acts as a promoter that will increase the effectiveness of lead by a third. Another way to increase the effectiveness of tetraethyl lead is to add the organic and completely combustible compound tertiary butyl acetate in amounts up to 1 per cent of the fuel. This is especially effective in many fuels of over 100 octane.

Chemistry can also help in the control of surface ignition. Some lead compounds such as oxides and oxyhalides act as catalysts for the promotion of oxidation of carbonaceous materials. In other words, the presence of some lead salts in some engine deposits can cause the deposits to oxidise and heat up in the presence of oxygen, at much lower initial temperatures than if the lead salts were not present. This increases the possibility of surface ignition from hot combustion chamber deposits. Fortunately, lead phosphates and related compounds do not act this way. Thus the addition of certain phosphorus compounds can greatly reduce the tendency towards surface ignition and rumble.



Pressure and noise records: (a) *normal combustion, clean engine;* (b) *knock, clean engine;* (c) *rumble without knock, engine with deposits;* (d) *rumble and knock, engine with deposits.*

Large-Scale Power by Direct Conversion

The direct conversion of heat to electricity for large-scale power would have many advantages. An assesment is made of three techniques whereby this may possibly be achieved.

By B. C. Lindley, B.Sc.(Eng.)

C. A. Parsons Nuclear Research Centre

THE development of steam turbo-alternators for large scale generation of electrical power is at present concerned with improvements in steam conditions which lead to small but worthwhile increases in overall thermal efficiency. Such improvements are usually accompanied by increased capital costs due to the materials and constructional methods required for operation at higher temperatures and pressures and the necessity for more complex plant to take advantage of cycle refinements. The trend of increases in capital, fuel and operating costs is largely offset by the use of progressively larger units which are more economic in all three respects. However, although the growth of the electricity supply system now permits block generation, the effect cannot be maintained indefinitely.

An ultimate limit in the performance of the steam cycle will be reached, perhaps exemplified by 1,000 MWe units operating on an air-steam binary cycle with steam conditions as high as 10,000 lb per sq. in (g) and 1,400° F, if the present trends continue. Coal or oil-burning plant with these conditions should be coming into service in about 15 or 20 years time and will achieve overall efficiencies of 45 per cent. High temperature nuclear reactor plant with similar conditions should follow later.

Since the limits of present techniques can be predicted with reasonable accuracy, it is not too early to consider further possible improvements to be incorporated in subsequent systems, and for which research and development effort should now be committed. It is appropriate to consider the thermal energy sources which are available for large scale electrical power generation, and the basic principles employed in the conversion to electrical energy.

The scope of this article will be restricted to the conversion of thermal energy, although a considerable effort is being devoted to the development of the fuel cell, in which chemical energy is converted directly to electrical energy. With further development, the fuel cell may have applications in both fossil and nuclear generating systems.

USE OF ENERGY SOURCES

In present technology, thermal energy is produced either by the combustion of fossil fuels or by fission in a nuclear reactor. Future developments in available chemical fuels and oxidants and in thermonuclear fusion reactors can be anticipated.

The efficiency, η, of a reversible (Carnot cycle) heat engine, working between a heat source at absolute temperature T_1 and a heat sink at absolute temperature T_0 is

$$\eta = \frac{T_1 - T_0}{T_0}$$

No practical heat engine can have an efficiency exceeding this value.

Heat engines in present use produce mechanical energy by the expansion of a working fluid, and the temperature difference $T_1 - T_0$ is proportional to a power of the expansion pressure ratio; Fig. 1 shows $\frac{T_1 - T_0}{T_1}$ as a function of the expansion pressure ratio $\frac{P_1}{P_0}$ for an expansion efficiency of 0·9. The temperature, T_0, at which heat is rejected is not less than ambient and, for practical reasons, may be appreciably higher.

In an internal combustion reciprocating engine, high temperatures can be utilised, but the expansion ratio is limited by practical difficulties. In a steam turbine, high expansion ratios are feasible but problems arise in utilising very high temperatures and pressures. In a gas turbine, the maximum temperature is limited by materials and the expansion ratio is dependent on the compressor power.

The elimination of rotating machinery by the use of generators in which thermal energy is converted directly to electrical energy would at once permit an increase in T_1 (and consequently a higher value of $T_1 - T_0$) since use can be made of high melting point materials either to operate at the temperature T_1, or to contain working fluid at this temperature. These materials usually have low tensile strength and are unsuitable for highly stressed rotating parts.

No known material can exist in the solid state at a temperature greater than about 3,800° C; if heat is rejected at 20° C, the limiting Carnot cycle efficiency for a solid-state conversion device is thus 0·93. Gases are restricted in temperature solely by the source of thermal energy.

Only low-grade fossil fuels are economic for large scale power generation, and the highest attainable flame temperatures with air are about 2,000° C. This can be increased a few hundred degrees by preheat, as shown in Fig. 2, although the gain is limited by chemical dissociation energy. The maximum temperature of combustion of any known fuel and oxidant is limited by dissociation and other losses to about 4,500° C. The gas temperature achievable in a gas-cooled fission reactor (in which the core contains only ceramic fissile, fertile and moderator materials) is limited by the melting points of materials and by heat transfer to 2,000° C to 2,500° C; the fuel centre temperature will be still higher.

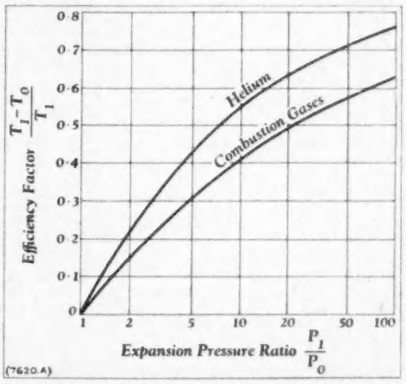


Fig. 1 Efficiency factor as a function of expansion pressure ratio, with expansion efficiency of 0·9.

It follows that the Carnot cycle efficiencies ultimately attainable with present thermal energy sources are in the range 0·75 to 0·93, compared with approximately 0·45 to 0·65 for present heat engines. Since the overall efficiency, for a given cycle, tends to be a constant fraction of the Carnot efficiency, appreciable increases in thermal efficiency are potentially available in systems which can utilise the highest feasible temperature of thermal energy sources. Such systems may be less complex than the ultimate steam plant; any simplification will tend to result in a lower capital cost.

METHODS OF DIRECT GENERATION

(1) *Thermoelectric*

Thermoelectric methods of generation depend on solid-state semiconductor thermopiles (assemblies of thermoelements or thermocouples), the "hot" junctions being maintained at a temperature T_1 and the "cold" junctions at a temperature T_0. The optimum thermal efficiency depends on the temperatures T_1 and T_0, and on a "figure of merit" which contains only electrical and thermal properties of the semiconductor material.

The transfer of thermal energy to a thermoelectric generator by a circulating fluid leads to low efficiency and raises the capital cost. Fossil-fuel heat sources and nuclear reactors with external thermoelectric generators are therefore unattractive; the only system with any prospect of economic thermoelectric power is a nuclear reactor in which the fuel elements themselves have thermoelectric properties. In this case the highest temperature in the reactor (fuel centre temperature) is utilised in the direct conversion process and results in the maximum feasible efficiency. Heat is rejected from the thermoelectric fuel elements at a low temperature, and the simple reactor generating plant could be moderated and cooled by low pressure water.

Research is therefore directed towards nuclear fuel materials which have a high figure of merit and are capable of operating at very high temperatures. Results to date show that the achievable figures of merit are low, particularly at high temperatures, and that there may be little prospect of very considerable further improvement.

(2) *Thermionic*

Thermionic methods of generation depend on the thermionic emission of electrons from a cathode maintained at a temperature T_1 to an anode maintained at a temperature T_0. Emission currents increase very steeply with temperature: T_1 must be high to obtain a good specific power output, and there is no advantage in a low T_0 since back emission becomes negligible, with decreasing T_0, at a relatively high temperature. The thermal efficiency depends principally on the work functions (the work required to remove one electron completely from the material) of the two electrodes, and the important losses are the radiation heat flux between the electrodes, and thermal conduction. The existence of a space charge (repelling newly-emitted electrons) limits the inter-electrode current but techniques are being developed to overcome this difficulty.

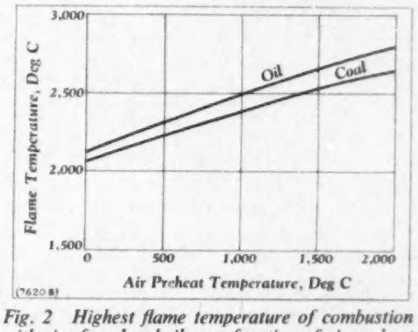


Fig. 2 Highest flame temperature of combustion with air of coal and oil, as a function of air preheat temperature.

As with the thermoelectric generator, fossil-fuel heat sources and nuclear reactors with external thermionic generators are unattractive. Degradation of the thermal energy is particularly inadmissible for thermionic generators in view of the steep efficiency-temperature characteristic.

Continued on next page

The thermionic nuclear fuel element offers the best prospect of economic nuclear power, since the cathode is either the fuel itself or in close thermal contact. Thermal energy is rejected at a relatively high temperature and a combination cycle with either conventional steam turbo-alternator plant or a thermoelectric generator is attractive. In the latter case, the thermoelectric material would be incorporated in the nuclear fuel element.

Research is directed principally towards the attainment of high cathode and low anode work functions in suitable materials, low cathode emissivity to reduce the radiation heat loss, and methods of eliminating the space charge. Experimental work already completed in the USA indicates that usefully high efficiency and specific power output will be achievable.

(3) *Magnetohydrodynamic*

Under suitable conditions gases are able to conduct electricity and the possibility arises of allowing a stream of conducting gas to interact with a magnetic field, converting the kinetic energy of the gas stream to electrical power. The study of the motion of an electrically conducting fluid in the presence of a magnetic field is known as magnetohydrodynamics; a device for electrical power production by such phenomena may be termed a magnetohydrodynamic generator.

Thermal energy is imparted to the gas, either in a nuclear reactor or through the combustion of fossil fuel, and is subsequently transformed by expansion to directed kinetic energy. A parallel may be drawn with a conventional alternator in which the directed kinetic energy of the metallic conductors in the rotor is converted to electrical power. The transfer of energy produced in furnace gases or in a nuclear reactor is but a means of directing a part of the energy, as shaft power, to the alternator. If the electrical conductors can be replaced by the moving combustion gases or reactor coolant, the generating plant will be simplified considerably, with the important advantage that the working fluid itself is now the prime mover.

Generation by thermoelectric and thermionic methods is being studied by many workers and detailed information is available in the technical literature.[1 2 3 4] However, although proposals for magnetohydrodynamic generation have been described,[5 6 7 8] an assessment of its feasibility is hampered by lack of experimental data. In the following section some of the necessary conditions are outlined in more detail.

ELECTRICALLY CONDUCTING GASES

Gases at low temperature are electrical insulators, the concentration of free electrons being negligible; high temperature and low pressure enhance dissociation into ions and free electrons. Even at flame temperatures, however, in the range 2,000° to 3,000° C, the free election concentration is small and it is only at very high temperatures (above 10,000° C) that gases become ionized to an appreciable extent. A highly-ionized electrically-conducting gas is termed a "plasma" and, at extremely high temperatures (above 10^7° C), plasmas can have a greater electrical conductivity than metals have at normal temperature. For the proposed method of generation to work, at the fairly low gas temperatures attainable with present thermal energy sources, it will usually be necessary to introduce electrically charged particles into the gas stream by auxiliary means to increase the electrical conductivity to a significant value, since the ranges of temperature are considerably lower than those required for thermal ionization in the majority of gases.

The ionization potential of a gas is a measure of the amount of energy required to dissociate a molecule into an ion and electron. Combustion gases and gases at present considered suitable as reactor coolants have high ionization potentials, in the range 12 to 16 eV (139,000° C to 186,000° C on the temperature scale). However, the injection of a very small concentration of a substance with low ionization potential leads to a disproportionately high increase in electrical conductivity. Suitable substances are sodium (5·14eV), potassium (4·33 eV) and caesium (3·88 eV), the latter being attractive only for closed cycle systems because of the high cost. Figs. 3 and 4 show the electrical conductivities of combustion gases (based on the properties of nitrogen) and of helium, at atmospheric pressure and with additions of potassium and caesium respectively. Helium, in view of its complete chemical inertness, would probably be used as the coolant in very high temperature thermal breeder reactors developed from the present OEEC Dragon project. An interesting possibility is the use of a condensing caesium vapour cycle, probably with a fast reactor; the electrical conductivity of the pure vapour will be higher than for a 1 per cent concentration by a factor of about 10.

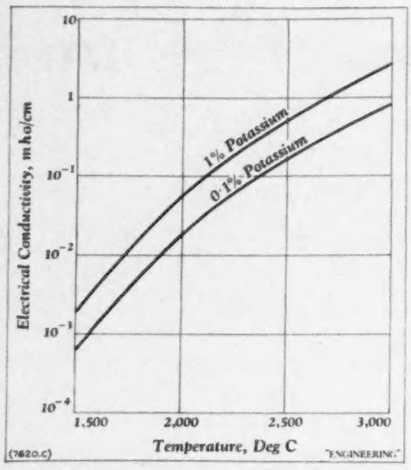


Fig. 3 Electrical conductivity of combustion gases containing small concentrations of potassium vapour, as a function of temperature.

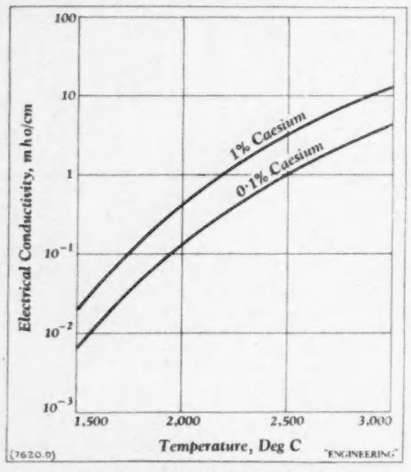


Fig. 4 Electrical conductivity of helium containing small concentrations of caesium vapour, as a function of temperature.

The electrical conductivities have been calculated by an approximate method but the values obtained give some indication of the expected properties. Modifications will occur if the ions and electrons are not in equilibrium concentrations and if the gases contain electronegative constituents, such as chlorine, water vapour, oxygen and carbon dioxide, which will capture electrons. The conductivity is not sensitive to pressure over a wide range.

Energy Transfer Processes

Interaction with magnetic fields can result in energy transfer from the charged particles only, whereas most of the kinetic energy in the gas stream is carried by uncharged particles, since the achievable ionisation corresponds to a very small fraction of the molecules. A mechanism has therefore to exist for the transfer of kinetic energy from the uncharged to the charged particles. In the metallic conductors of a conventional alternator, this process takes place through the positive nuclei in the crystal lattice. When moved in the magnetic field, electrons flowing in the metal experience a retarding force which is transmitted to the positive nuclei by attraction forces. Since the nuclei are fixed in the crystal lattice, the whole conductor loses kinetic energy. The process is only possible because most of the atoms contribute conduction electrons and the atomic particles are so close that interparticle forces are very large.

These conditions are not satisfied in a gas; energy transfer must be by attraction forces and collisions between particles. The transfer of energy from the gas stream to an external load circuit results in retardation of the electrons; a possible mechanism is that the attraction forces retard the positive ions and energy is transferred from the gas molecules by direct elastic collisions. The effectiveness of this process cannot be shown theoretically since the relevant experimental data are not available.

In the simplest conception of the magnetohydrodynamic generator, a transverse magnetic field is imposed and the output voltage is produced in a mutually perpendicular direction. To maintain charge continuity, electrons must be injected continuously, for example, by a thermionic cathode. A similar scheme, but with radial geometry, is also possible; in this a radial magnetic field deflects the electrons to give a circumferential flow while the positive ions, having a mass thousands of times greater than the electrons, continue in the axial direction but suffer retardation through the attraction forces of the electrons.

Induction methods, producing alternating current, are more attractive in many respects than those requiring electron removal and injection. The load circuit does not include the gas, but the transfer of energy is nevertheless dependent on currents flowing in the gas. In one arrangement a circumferential alternating electron current, produced by an alternating radial magnetic field, acts as a primary transformer current coupled into a secondary output winding. Other schemes can be conceived in which energy is extracted from a pulsed stream of ionised particles; if the pulsed ionisation is thermal, the mean electrical conductivity is considerably greater than would correspond to the mean temperature of the gas, and the materials problem is eased.

Design Considerations

To achieve high generator efficiency, the cycle efficiency of the expansion process must itself be high. Reference to Fig. 1 shows that, in an "impulse" generator, in which the pressure is constant, high efficiency $\left(\frac{T_1 - T_0}{T_1}\right)$ is obtained by the use of very high pressure ratios, which result in supersonic flow and the necessity for a supersonic nozzle design; similar nozzle configurations are used in wind tunnels and for rocket propulsion. Table I below shows typical parameters.

TABLE I.—*Typical parameters of a magnetohydrodynamic generator design.*

Expansion isentropic efficiency = 0·9

	Helium	Combustion gases
Temperature before expansion, T_1 °C	2,500	2,500
Temperature after expansion, T_0 C	800	800
$\frac{T_1 - T_0}{T_1}$	0·61	0·61
Velocity, ft per sec	13,900	6,400
Mach number	2·2	3·0
Expansion pressure ratio	17·5	95

A "reaction" generator, in which the velocity is constant, may also be feasible.

The high temperature region in the combustion chamber or at exit from the reactor will

Wide Programme for Heating and Ventilating

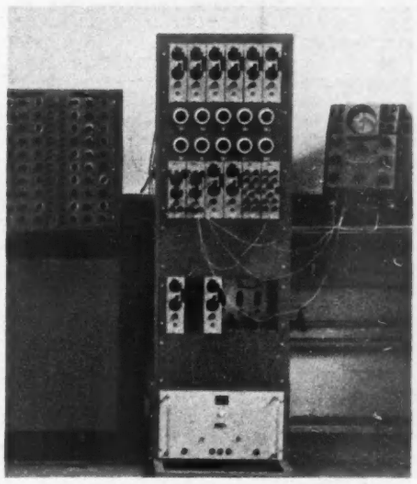
Britain's most recent Research Association was opened this month by the Minister for Science, Lord Hailsham. In the opening remarks of his speech, the Minister pointed out that the new Heating and Ventilating Research Association had grown rapidly from its humble beginnings as a research council into a fully fledged association in only three and a half years. This rate of development is unusually high and serves as an indication of the energy and enthusiasm of those who have been connected with its formation.

Although the present status was actually granted in July of last year, they did not have premises of their own until quite recently; hence the delay in holding the official opening ceremony. However, there has been no delay in getting on with the job of research; on the contrary, they have undertaken a wide programme of work and already have much of it well under way.

The range of their programme goes well beyond the sponsored work which is carried out on behalf of constituent members and even includes such all-embracing topics as operational research. At first sight this may appear to be ambitious for such a newly formed body; but in fact this is not so, especially since any economy of labour and materials is most welcome in an industry where site work accounts for a major proportion of the total cost.

One of the topics currently being investigated is that of noise reduction, which is a subject demanding increased attention right throughout industry. This problem is particularly important at the moment because modern design trends in heating and ventilation, for example, small-bore pipes, are tending to oppose sociological trends by appreciably increasing the overall noise level in buildings.

This problem is being approached in several ways. First the techniques of noise measurement (particularly fan noise) are being studied. A special panel of representatives of prominent firms in the fan industry has been formed to assist the experts at the HVRA in selecting suitable methods for measuring both the total sound power and its frequency distribution. A second approach has been to study the design of ducts and fittings in order to find means of reducing losses. This approach has a dual outcome in that it leads to increased efficiency as well as reduced noise. As a third avenue of approach, investigations are being carried out to determine the critical speed at which water flowing through pipes gives rise to objectionable noise. Noise reduction should lead to more comfortable living and more efficient work.



As part of their research into the intermittent heating of large buildings, the HVRA are designing and constructing electrical analogue equipment.

Concluding **Large-Scale Power by Direct Conversion**

facilitate ionization. The rapid reduction in temperature during expansion may not have an immediate effect on the ion-electron concentration (although recombination rates are increased at lower temperatures), since the time interval for passage through the expansion nozzle and generator will generally be only a few milliseconds. There is thus an incentive to reduce the length of the expansion nozzle and generator duct. From every other consideration the generator design becomes more favourable as the size is increased since, relative to the output, heat losses, electrode losses and field coil weight and power consumption are all reduced. It might be useful in some cases to arrange for isothermal expansion. This could be achieved readily in a combustor by burning fuel in the expansion nozzle; in a reactor the increased voltage necessary would probably have too great an effect on the fuel investment.

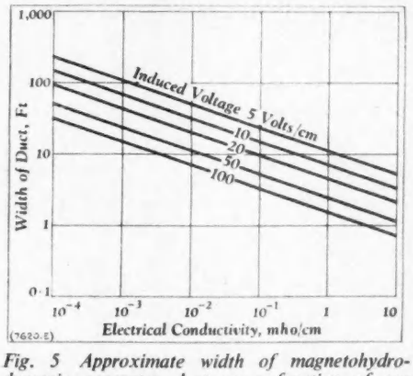


Fig. 5 Approximate width of magnetohydrodynamic generator duct as a function of gas electrical conductivity and induced voltage. Aspect ratio of square section duct, 8.

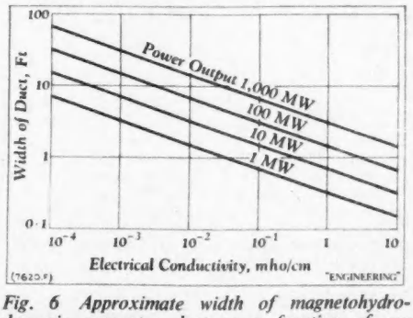


Fig. 6 Approximate width of magnetohydrodynamic generator duct as a function of gas electrical conductivity and power output. Aspect ratio of square section duct, 8. Induced voltage, 100 volts per cm.

In the simplest case, the induced voltage is proportional to the product of stream velocity and magnetic field strength. Fig. 5 shows a rough estimate of the size of a 100 MWe generator, as a function of the gas electrical conductivity. The dimension given is the mean width of a square-section duct with an aspect ratio of 8. An induced voltage of 100 volts per centimetre width of duct corresponds to a velocity of 13,000 ft per sec. and a magnetic field of 25,000 gauss. Fig. 6 shows the size for a range of power output, with an induced voltage of 100 volt per cm.

The materials problem is mainly dependent on the nature of the working fluid. In a generator working on the products of coal or oil combustion at the envisaged temperatures corrosive effects in the combustion chamber, generator and any form of recuperator or regenerator are likely to be very severe, and may even prove insuperable. In the closed cycle reactor plant an inert gas can be used which, although it contains a small concentration of metal vapour, will have relatively little tendency to attack or coat material surfaces. If the very high temperature reactor is itself feasible, the generator will present no further materials problems, since the conditions of operation will be less severe than in the reactor.

CONCLUSIONS

All three methods for the direct generation of electricity permit a very considerable increase in the maximum cycle temperature of heat engines for the large-scale production of electrical energy and hence, potentially, a very worthwhile gain in thermal efficiency, coupled with reductions in capital cost.

The envisaged temperatures in the range 1,500° to 3,000° C are achievable by the combustion with air of fossil fuels (although acute problems arise in operating such systems at very high temperatures) and will eventually be attained in highly developed forms of nuclear fission reactor.

The utilisation of higher ranges of temperature to achieve high thermal efficiency in gas cooled reactor plant may be realised in two stages, typified by overall thermal efficiencies of 50 and 60 per cent respectively; first, the use of thermionic diode fuel elements, possibly incorporating a thermoelectric stage, followed later by forms of magnetohydrodynamic generator coupled to a very high temperature reactor, in both systems utilising a steam cycle over the lower range of temperature.

The present concepts of direct generation are perhaps rather crude and long-term research in this field is likely to lead to more sophisticated solutions. Direct generation systems are still in their infancy but they may well, in time, alter or modify present day conventional heat engine cycles.

Acknowledgement

The author is indebted to the directors of C. A. Parsons and Company for permission to publish this article; the opinions expressed are his own.

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Refrigerators Change

THE latest figures available show that only one British home in five has a refrigerator. The market is still large therefore, and manufacturers are doing their best to fill it. It is estimated that there are no fewer than 80 makers producing more than 500 models. There should be no lack of choice.

In general there has been no major change in operating principles with the one major exception of the GEC cold box, now in its prototype form but well on the way to the commercial market. It uses the Peltier effect (whereby the passage of an electric current through the junction of two dissimilar metals causes cooling) with which manufacturers have been experimenting vigorously for the last few years. Westinghouse of America have also produced a prototype refrigerator using this principle; it is a much larger machine and has a capacity of about 9 cu. ft.

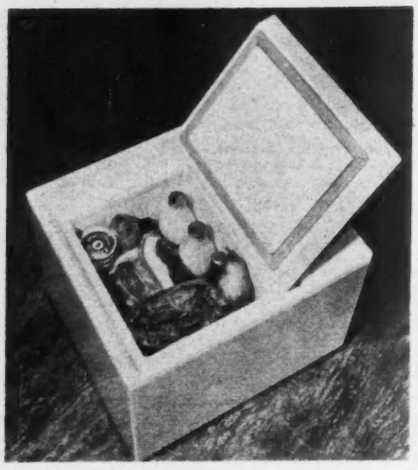
The great advantage of the Peltier effect is that it involves no moving parts and no chemical refrigerants, either gases or liquids. The result is therefore a very light article that is robust and does not have to be kept (at least of itself) one way up. Direct current is used as the power, and the GEC model will operate from a car battery. It has a capacity of about 1 cu. ft and while it is not designed to freeze the contents, it will lower the temperature by about 20 or 30° C. Apart from keeping perishables cool, the box will find many applications in industry and medicine.

Totally different in concept from the conventional enamel finish is another Westinghouse refrigerator which is designed as a piece of room furniture such as might form the divider between the dining and kitchen areas. The top is surmounted by a glazed cabinet with sliding doors on one side and swing doors on the other to give access from both sides. In the main body there are sliding drawers for cooling and for freezing, and there are outlets for portable electrical appliances. In fact it takes the place of a sideboard and larder.

as is evidenced by the number of people who are changing small refrigerators for bigger ones; therefore design must slim down the lines. One way is to plan the doors to open within the width of the cabinet, enabling the unit to stand flush with the rest of the kitchen equipment.

Of the other changes in design that have occurred during the past year the chief are probably the use of plastics materials, the fitting of adjustable shelves and the wider choice of colours. A great many of the components are now made in plastics, which has helped both in dimensions and price. Complete inner cabinets, door linings, evaporator containers, crispers, trays, and surrounds are all in plastics.

Adjustable shelves are a great boon for changing needs; it is rare that food items are always the same size. Storage has been helped too by the provision of full width "dairy" strips in the door panel and of special compartments for butter where it will remain "spreadable." With the considerable increase in the sale of frozen foods, storage space for them has become more important—in fact, of course, sales and storage are linked.



(*Above*) *The new GEC cold box, now in prototype form, utilises the Peltier effect.*

(*Left*) *Largest of the domestic refrigerators is the Foodarama with a capacity of 18 cu. ft. It will hold 207 lb of frozen food.*

The upper storage cabinet does not extend over the whole of the top surface but leaves enough free space for a working table or to rest trays on while moving them from the kitchen to the dining area. Exterior finish is a wood veneer to match the surroundings, and special materials are used for insulation, so allowing the walls to be much thinner than usual.

The second illustration shows what is believed to be the largest domestic refrigerator on the market. It is the Kelvinator Foodarama with a capacity of 12 cu. ft for storage and another 6 cu. ft for freezing; 207 lb of frozen food can be stored. The Foodarama also illustrates another trend in modern styling; namely the use of minimum floor space. As kitchens continue to be small, it becomes vitally important to save on space. Yet the demand is for larger capacity

The idea current until a year or so ago that all kitchen items should be white is undergoing a steady change. The pleasanter effect of creams and pastel shades is being exploited and refrigerators are no exception. They are appearing in green, pink and red. Inside there are paler shades of turquoise, ice blue, beige, pearl grey, and pale green. Tops are both heatproof and colourful. It is an interesting footnote on design and use of materials that prices are no higher now than in 1939, while capacity has been increased per unit volume.

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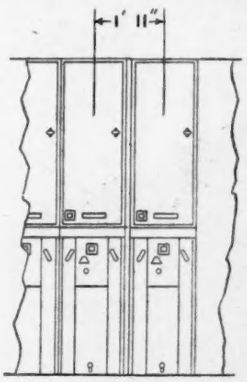

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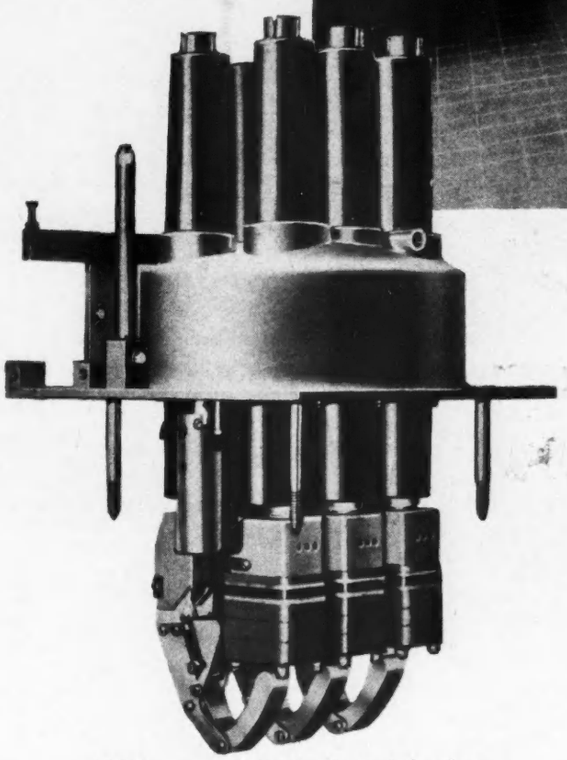

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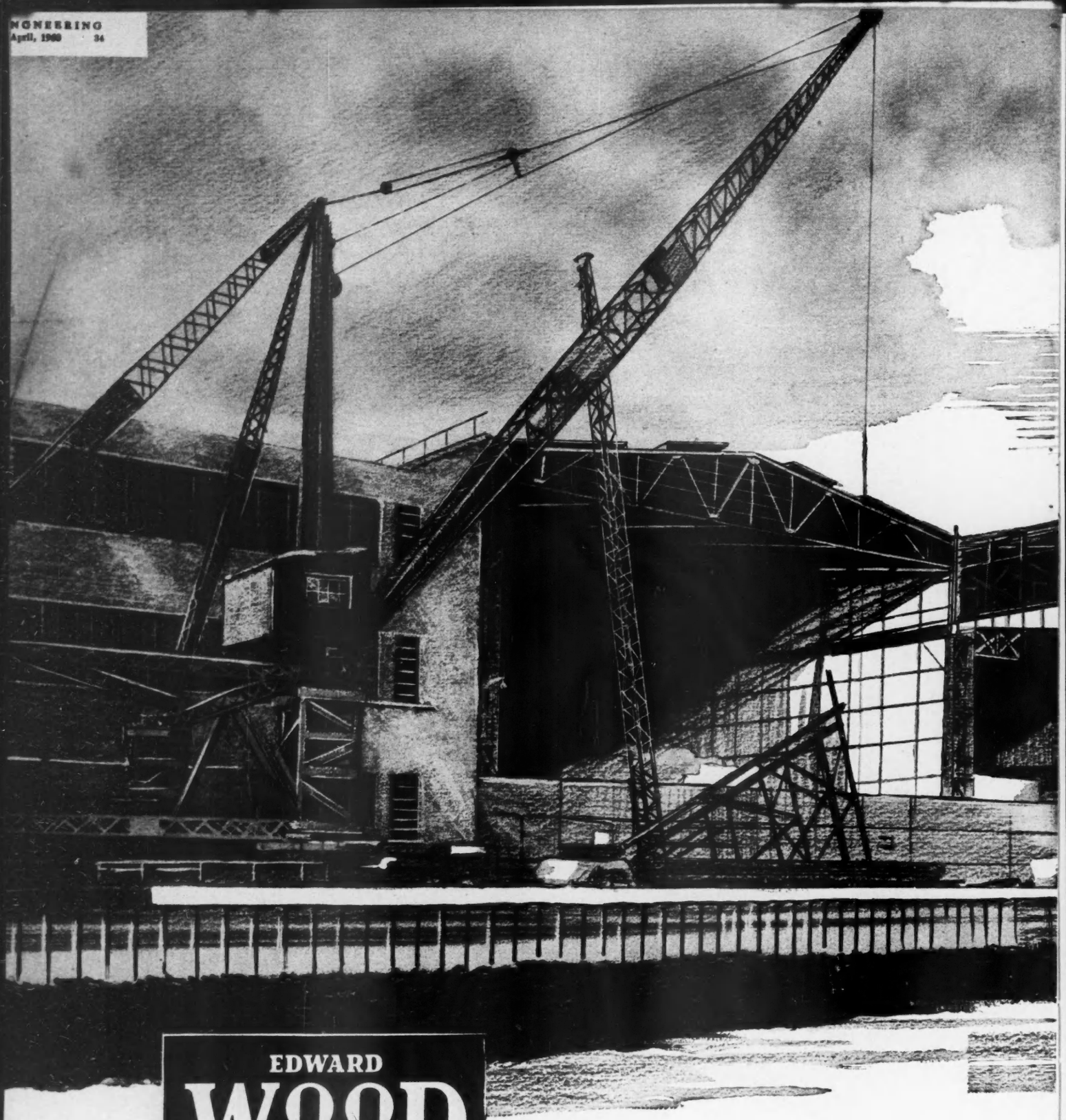

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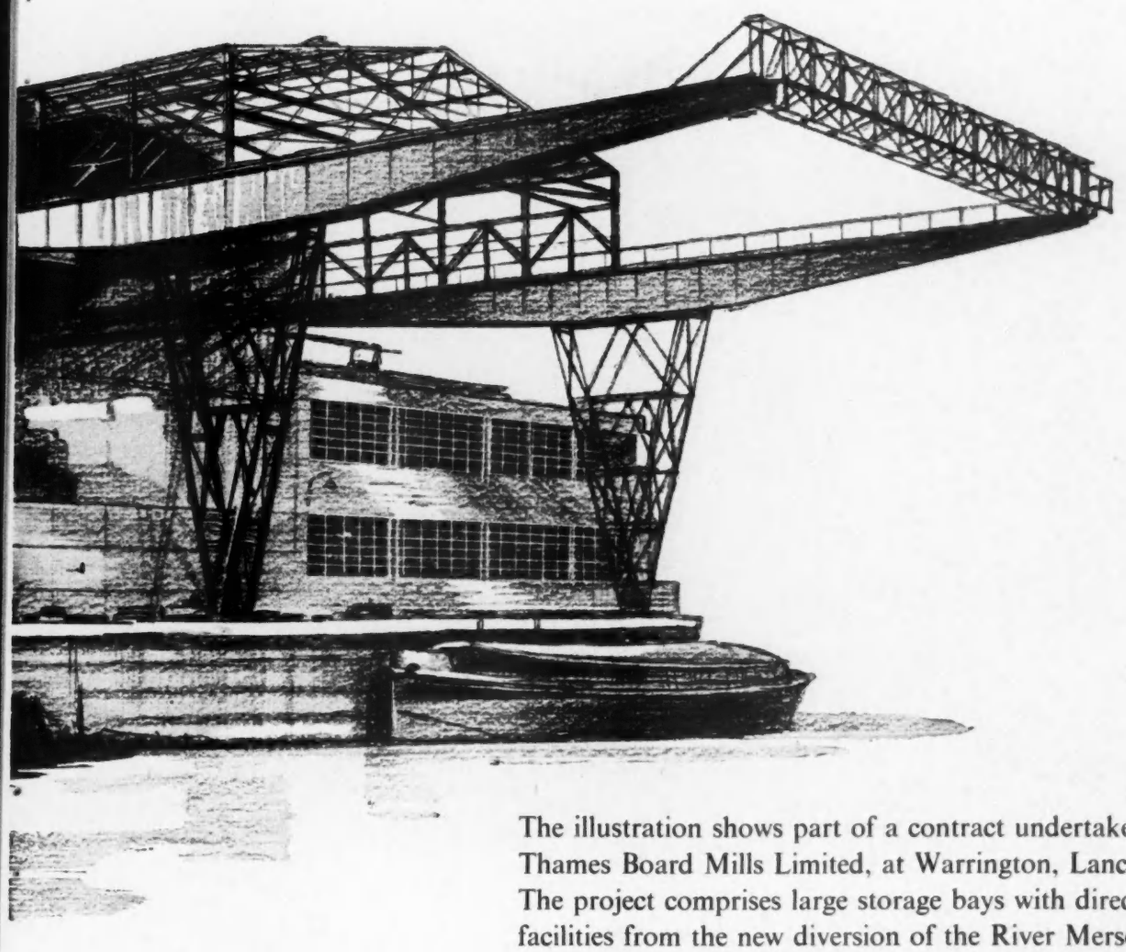

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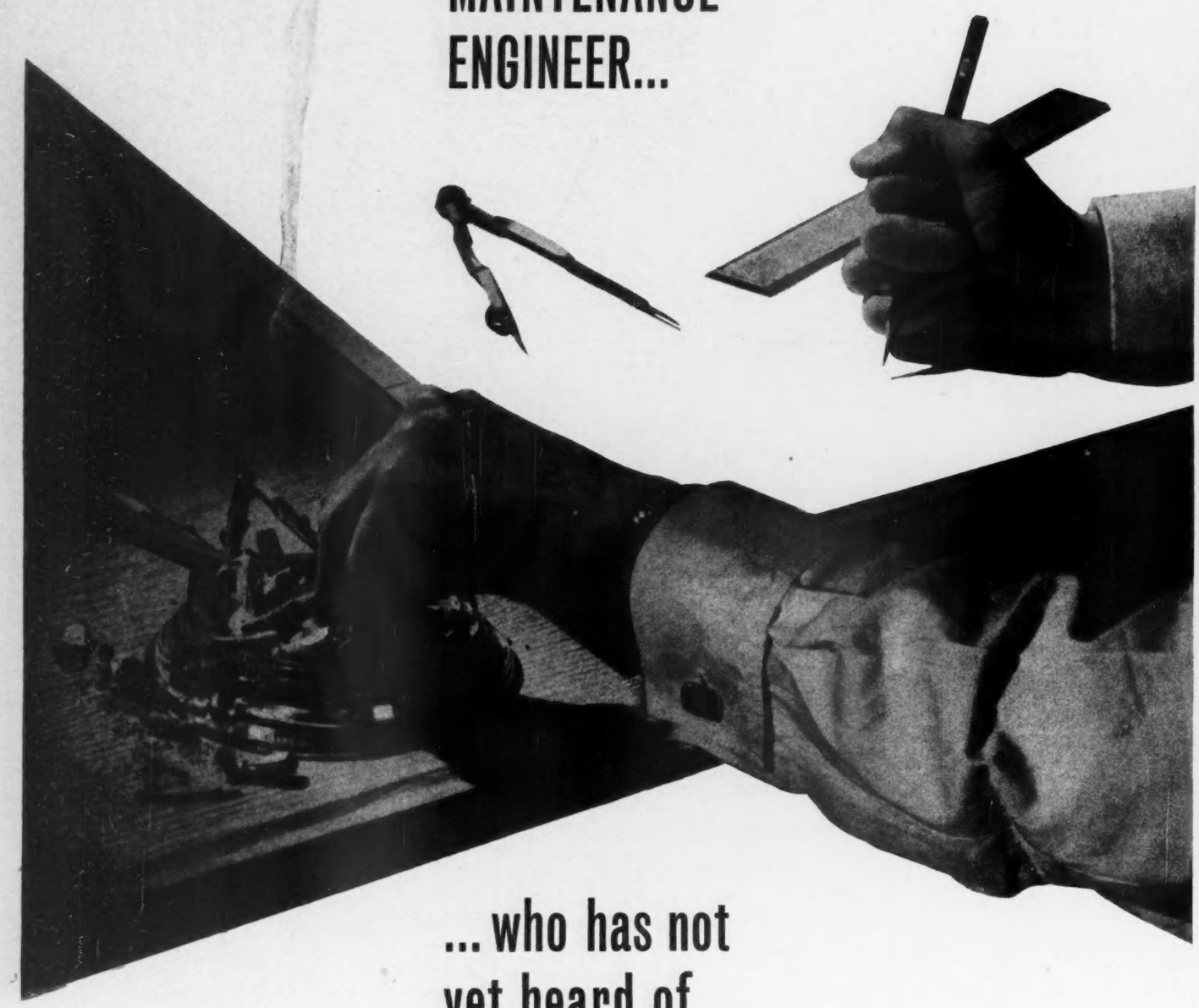

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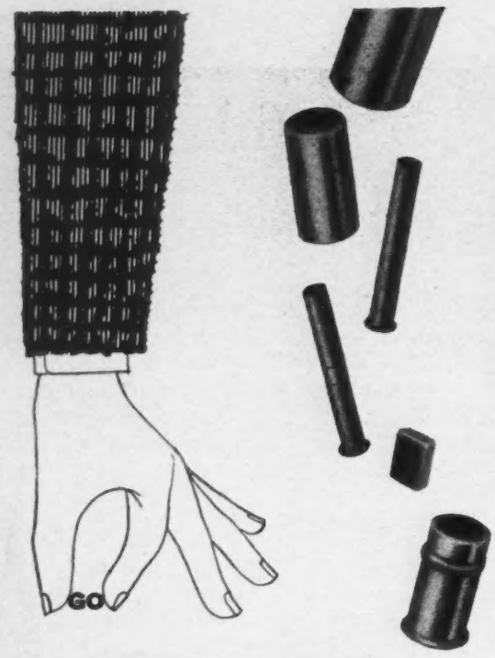

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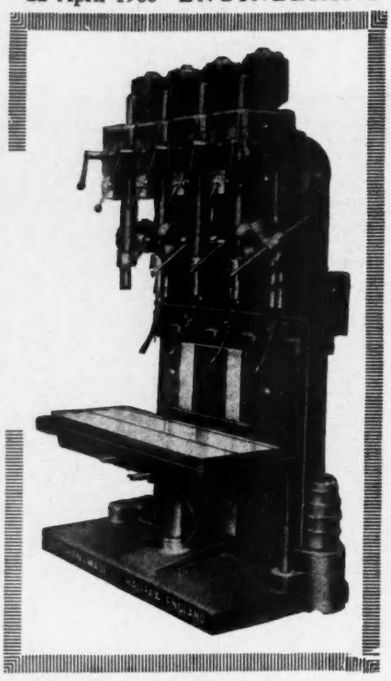

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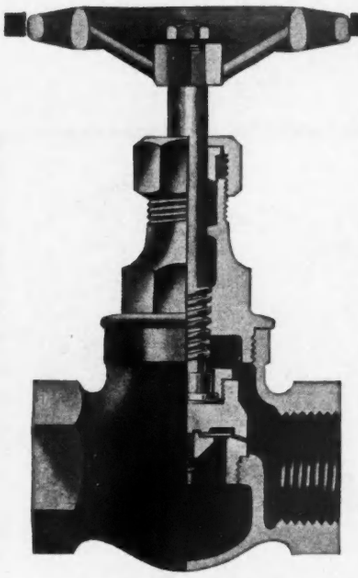

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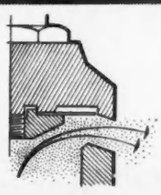

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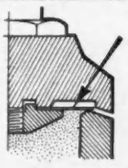
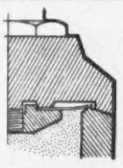


In 'Pre-shut' position flow and pipe scale held back by *Flexible Titanium Disk.* Patent No. 822147



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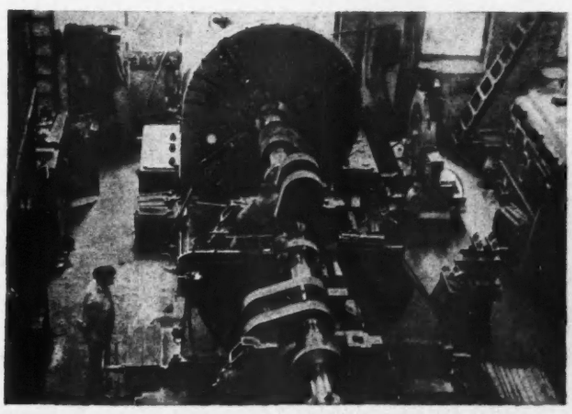

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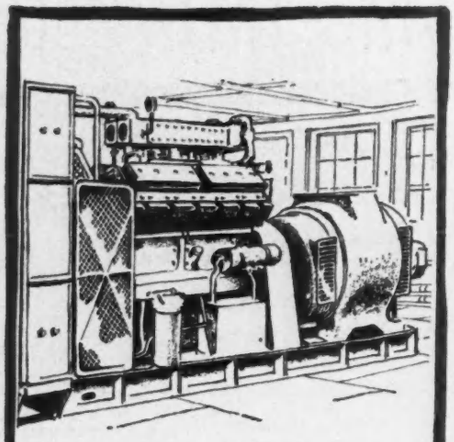

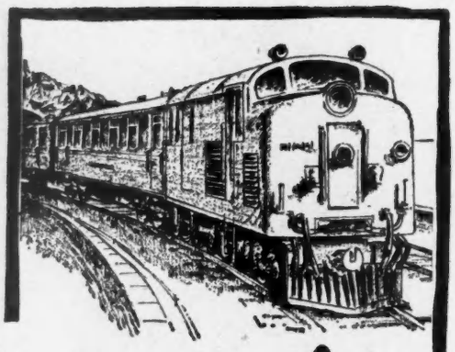

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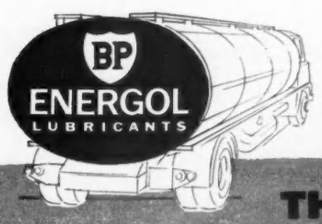

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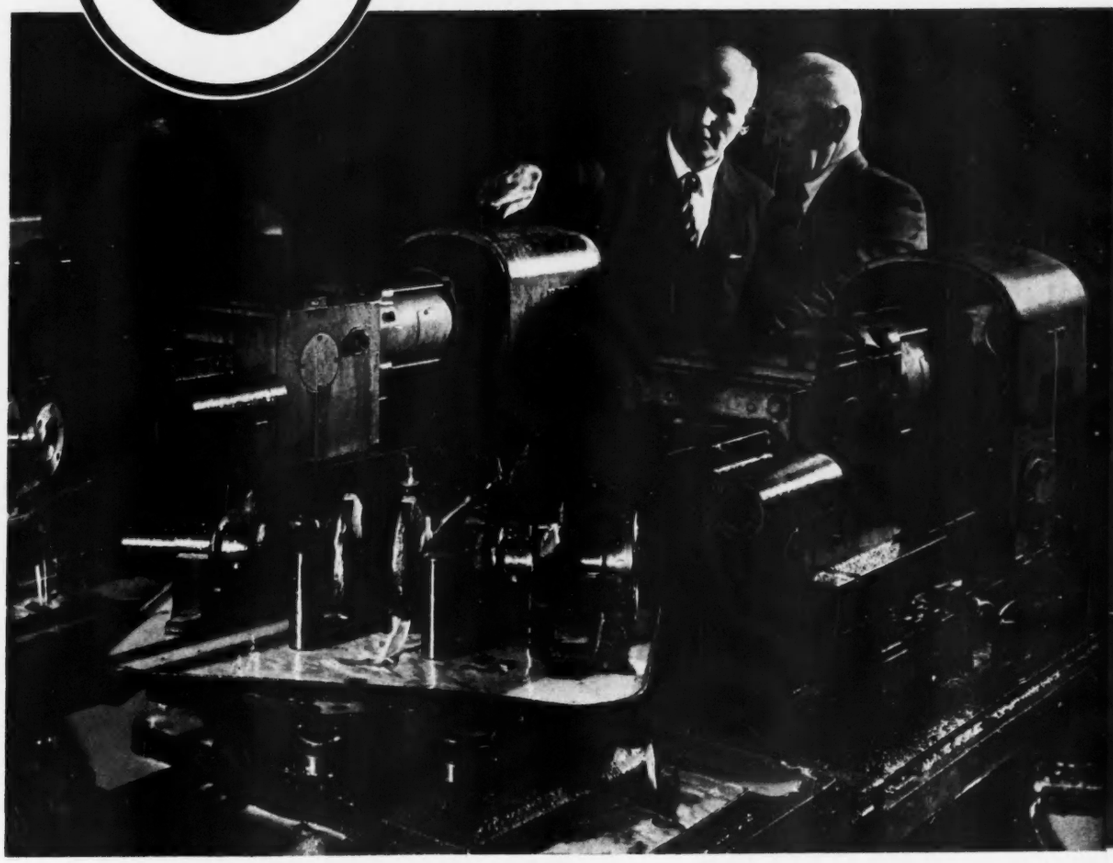


"REGAL OIL (R & O) BY ITS CONSISTENT HIGH QUALITY MEETS OUR NEED FOR COMPLETE DEPENDABILITY WHICH IS ESSENTIAL IN THIS KIND OF WORK"

5 special features make Regent Regal (R & O) Oils invaluable for all hydraulic operations

INCREASING USE IN BRITISH INDUSTRY

To operate efficiently, even the simplest hydraulic system must be kept absolutely clean. This means that wear must be reduced, rust eliminated and gum and sludge deposits prevented.
Regal Oils (R & O) do all this, and give long-lasting protection to all industrial hydraulic systems.
Which is why more and more British industries are turning to Regal Oils (R & O) for high quality performance and complete dependability.

RESIST OXIDATION

Regal Oils (R & O) contain powerful oxidation inhibitors which minimise the possibility of gum or sludge deposits and increase intervals between drain periods.

PREVENT RUST

Regal Oil (R & O) contain a rust inhibitor which 'plates out' on metal surfaces, forming a tenacious film that is impervious to rusting action of moisture and water. This eliminates the damage so often caused by rust.

PREVENT WEAR

Regal Oils (R & O) cling to metal surfaces and penetrate between closely fitted bearing surfaces, giving adequate lubrication. This way wear is minimised.

ANTI-FOAMING

Regal Oils (R & O) are processed so that they are highly resistant to foaming. This characteristic is improved by additive treatment.

WIDE VISCOSITY RANGE

Regal Oils (R & O) are manufactured in different viscosity grades to meet every operating condition and give excellent performance at both high and low temperatures.
Regent Regal Oils (R & O) meet the requirements of the British Hydraulic Pump Manufacturers. The range comprises:
Regal Oil A (R & O). Regal Oil B (R & O). Regal Oil CC (R & O). Regal Oil C (R & O). Regal Oil PC (R & O). Regal Oil PE (R & O). (R & O) Oil AA.

REGENT

REGENT OIL COMPANY LTD., 117 PARK STREET, LONDON, W.1

FERODO THE FIRST NAME IN FRICTION

Ferodo First

. . . because Ferodo have a sound answer to every friction problem—from small linings for aircraft instrument clutches to huge overload clutch facings for an icebreaker propeller shaft.
. . . because Ferodo products promise longer life—smoother braking, transmission and control—and the backing of the greatest research and development organisation of its kind in the world.

FERODO

FRICTION LININGS FOR INDUSTRY

Brake Linings · Disc Brake Pads
Clutch Facings · Sintered Metals

FERODO LIMITED · CHAPEL-EN-LE-FRITH
A Member of the Turner & Newall Organisation

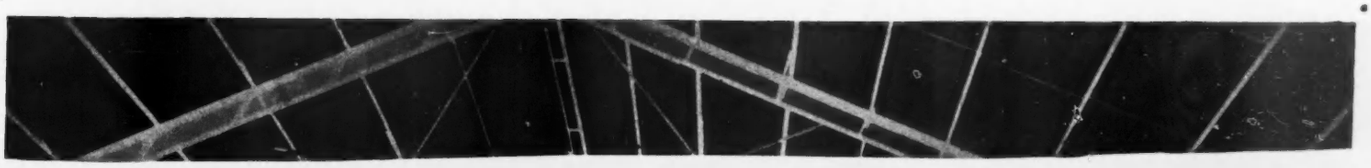
9/27

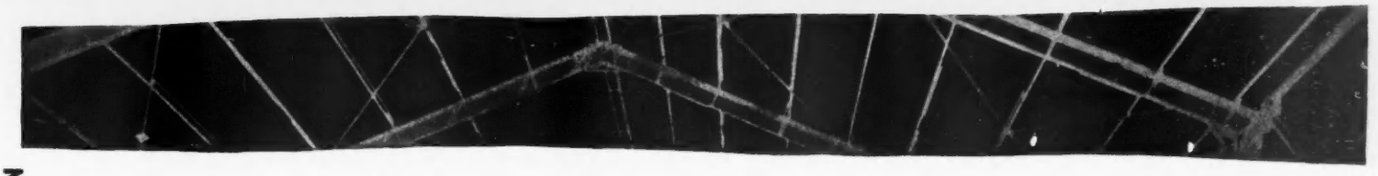
FABRICATION • ERECTION • DESIGN • FABRICATION • ERECTION • DESIGN • FABRICATION • ERECTION • DESIGN • FABRICATION

• DESIGN •

The Portal Roof...

• ERECTION •



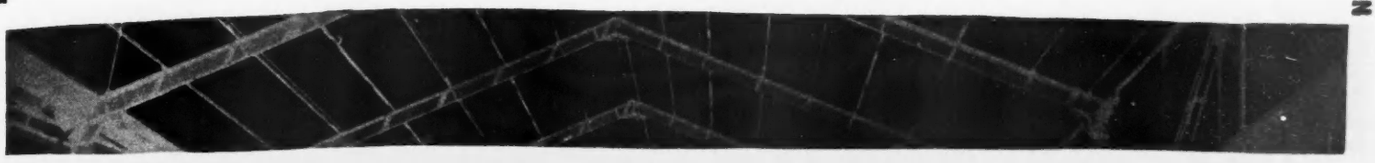


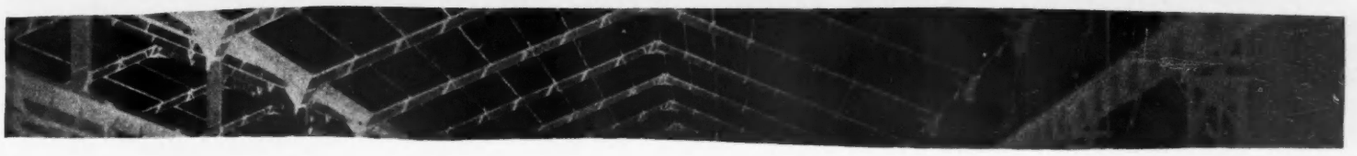
DESIGN • FABRICATION • ERECTION

. . modern construction for the modern factory . . . .

Ever in the forefront of modern development, Lambhill show this example of a welded Portal Roof—a twin—span construction with spans measuring 70 ft. by 500 ft. giving maximum unobstructed headroom. There are no members below the rafter line to accumulate dust and dirt; the construction permits easy complete insulation. Maintenance costs are low.

DESIGN • FABRICATION • ERECTION





DESIGN • FABRICATION • ERECTION

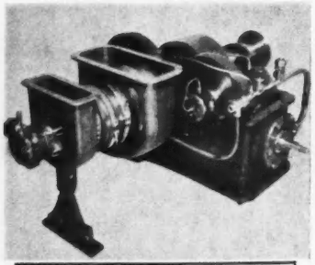
LAMBHILL
IRONWORKS LIMITED

HEAD OFFICE: LAMBHILL, GLASGOW. N.2.
Telephone: POSSIL 8386/7/8 *Telegrams*: "ERECTIONS" Glasgow
ALSO AT: LONDON NEWCASTLE AND SHEFFIELD

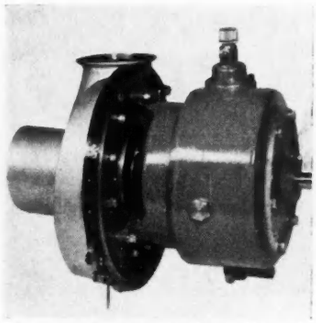
CONSTRUCTION

DESIGN • FABRICATION • ERECTION

Axial Flow Air Compressor

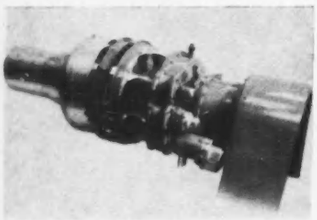


350 H.P. Turbine for Gasifier

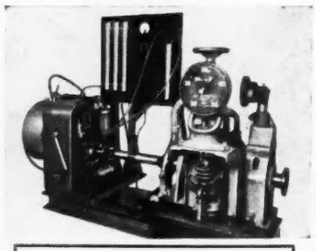


Radial Flow Free Power Turbine

GAS TURBINE DRIVEN MACHINERY



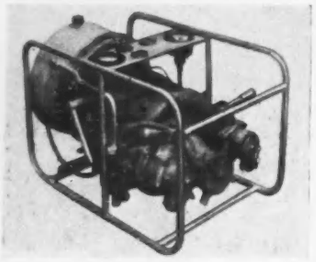
500 H.P. "Basilisk" Gas Turbine (Shaft Power and Air Bleed versions)



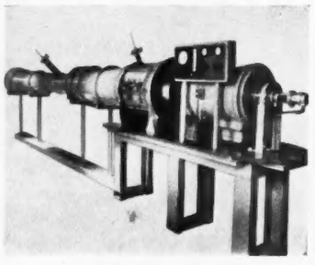
Instructional and Test Set

AXIAL AND RADIAL FLOW AIR COMPRESSORS

500 G.P.M. Lightweight Pumping Set



Axial Flow Compressor for Instructional Use



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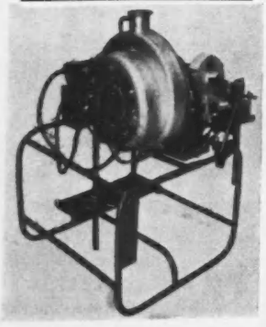
Limited

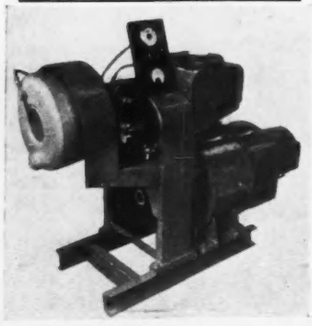
HARWICH ESSEX

Telephone: HARWICH 116

Bleed Air Engines up to 2.5 p.p.s. at 60. p.s.i.



Generating Sets up to 400 kW.



High Performance Suction Fan

HIGH EFFICIENCY AIR FILTRATION

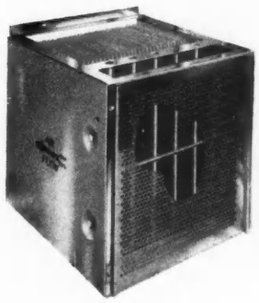
to meet exacting process conditions in all types of industries is provided

by

Precipitron

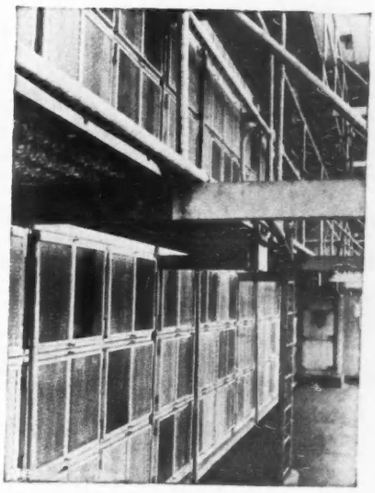
REG TRADE MARK SOLE LICENSEES

ELECTROSTATIC AIR FILTER

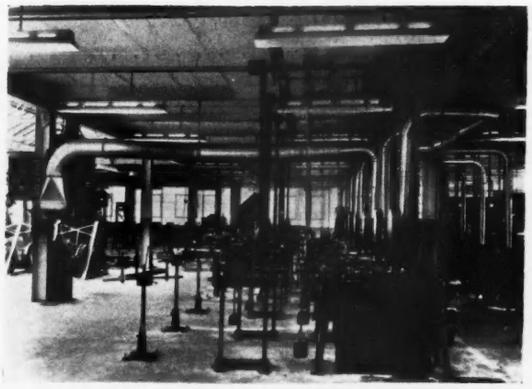


Electrostatic air cleaning was pioneered by Sturtevant in the United Kingdom with PRECIPITRON Air Filter. Our publication D7107 will be sent on request.

PRECIPITRON Electrostatic Air Filter is the finest air cleaner available and thousands are now used in industries ranging from precision engineering to brewing, from plastics to food manufacturing. It has a constant high filtration efficiency, constant low resistance and it removes *ALL* airborne impurities down to less than 0·01 micron in size.



Part of the PRECIPITRON installation at the Derby High Altitude Test Station of Rolls-Royce Ltd.



PRECIPITRON installation for the removal of oil mist from a battery of automatics in the Needle Bearing department of the Torrington Co. Ltd., Coventry.

OIL MIST REMOVED BY PRECIPITRON

PRECIPITRON Electrostatic Filter removes all oil mist generated by high speed machining operations at such high efficiency that

- **The filtered air may be safely returned directly to the workshop.**
- **Heat losses are avoided.**
- **Working conditions are improved.**
- **Oil is salvaged.**
- **Damaging effects to machinery, fittings and building surfaces are prevented.**

STURTEVANT ENGINEERING CO. LTD.

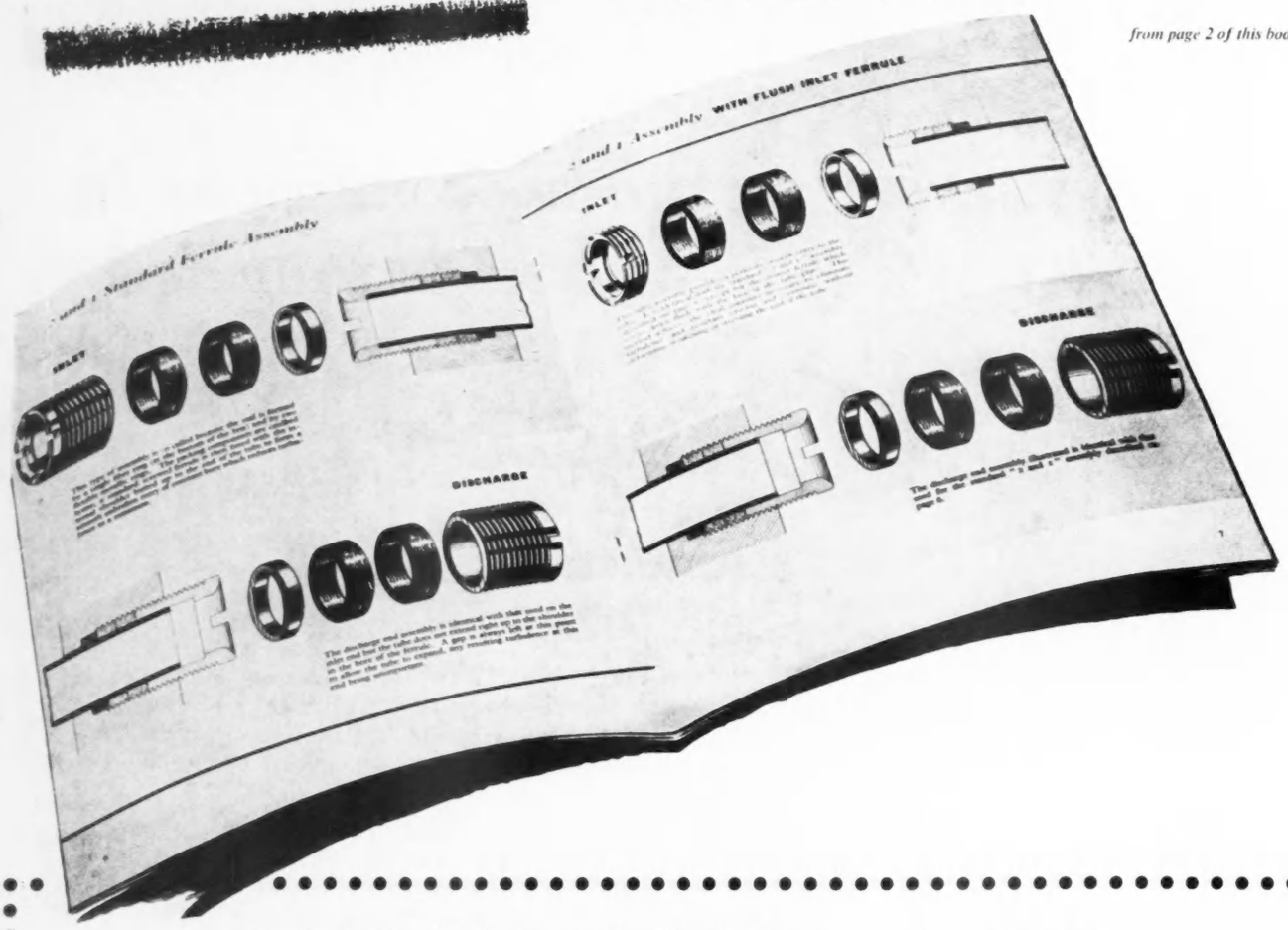
Southern House, Cannon Street, LONDON, E. C. 4.

AUSTRALIA: STURTEVANT ENGINEERING CO. (AUSTRALASIA) LTD. 400 SUSSEX STREET SYDNEY N.S.W.

Quote!

"The CRANE Condenser Process was developed so that the tubes of conventional straight tube heat exchangers might be secured and effectively sealed off in their tube plates, while still allowing them freedom to move axially—**without deformation or damage to the tube ends.**"

from page 2 of this booklet.



This is a booklet which has been produced for all engineers who are concerned with the manufacture or the performance of straight tube heat exchangers, and especially marine and land based condensers.

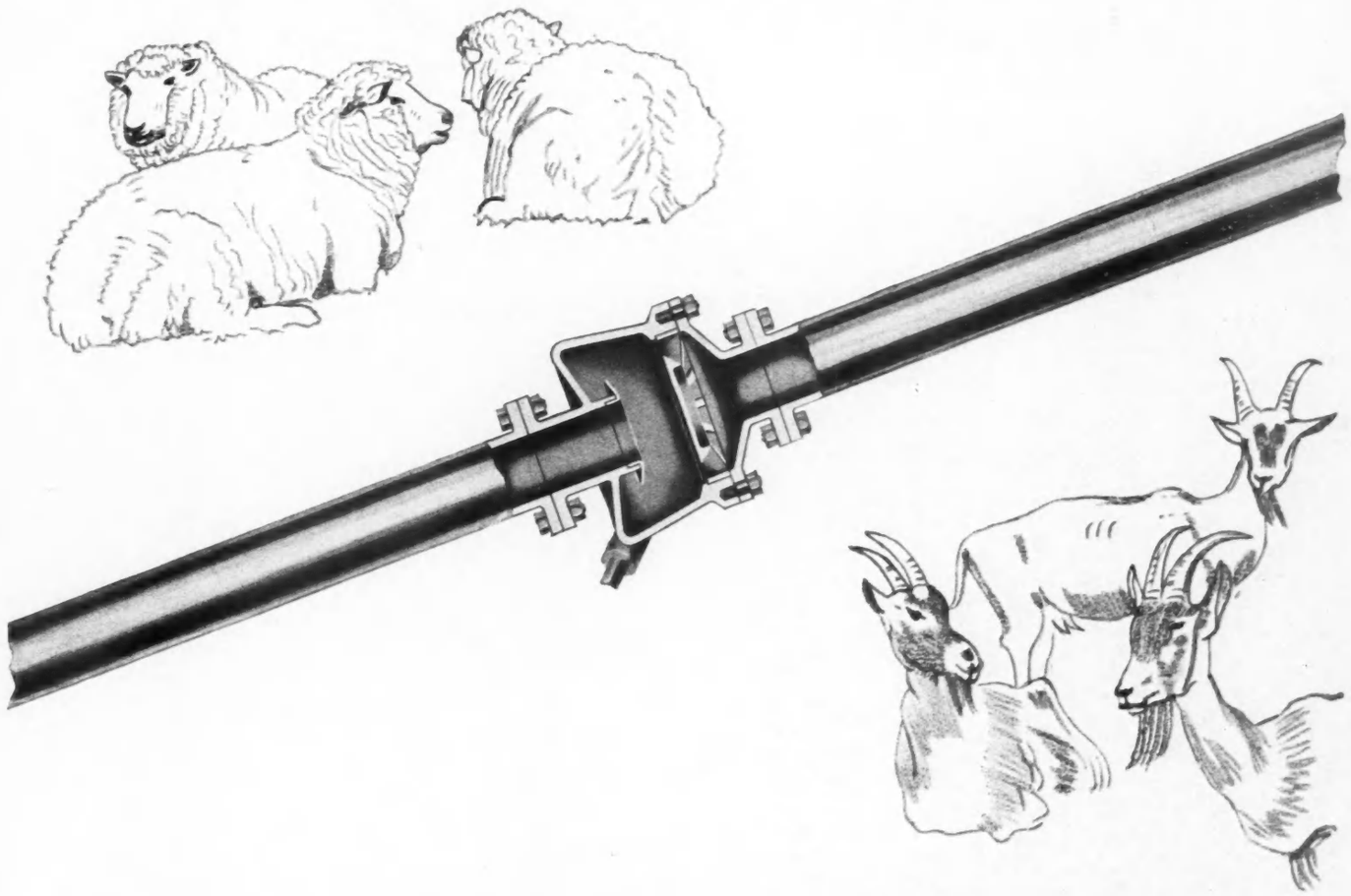
The contents of the booklet include a description of the CRANE Condenser Process, the problems which arise in sealing against leakage in all conditions of marine and land service, descriptions of various assemblies, and other information which is allied to the subject.

Copies of the CRANE Condenser Process Booklet can be obtained from Crane Packing Limited of Slough, Bucks, England.

ISSUED BY THE CONDENSER PROCESS DIVISION OF

Crane Packing LTD OF SLOUGH ENGLAND A COMPANY

Sheep and goats!
Oil and Water!
it's all a matter of separation



We cannot deal with sheep or goats, but the 'Supreme Vortex' pipe line separator is unsurpassed for separating . . . .

Moisture **and oil drops from compressed air**
Moisture **from steam**
Dirt particles **from gases**

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SEPARATOR DIVISION

J. H. CARRUTHERS & CO. LTD., COLLEGE MILTON, EAST KILBRIDE, GLASGOW.
Telephone: East Kilbride 20591 Telegrams: 'Hoisting' East Kilbride

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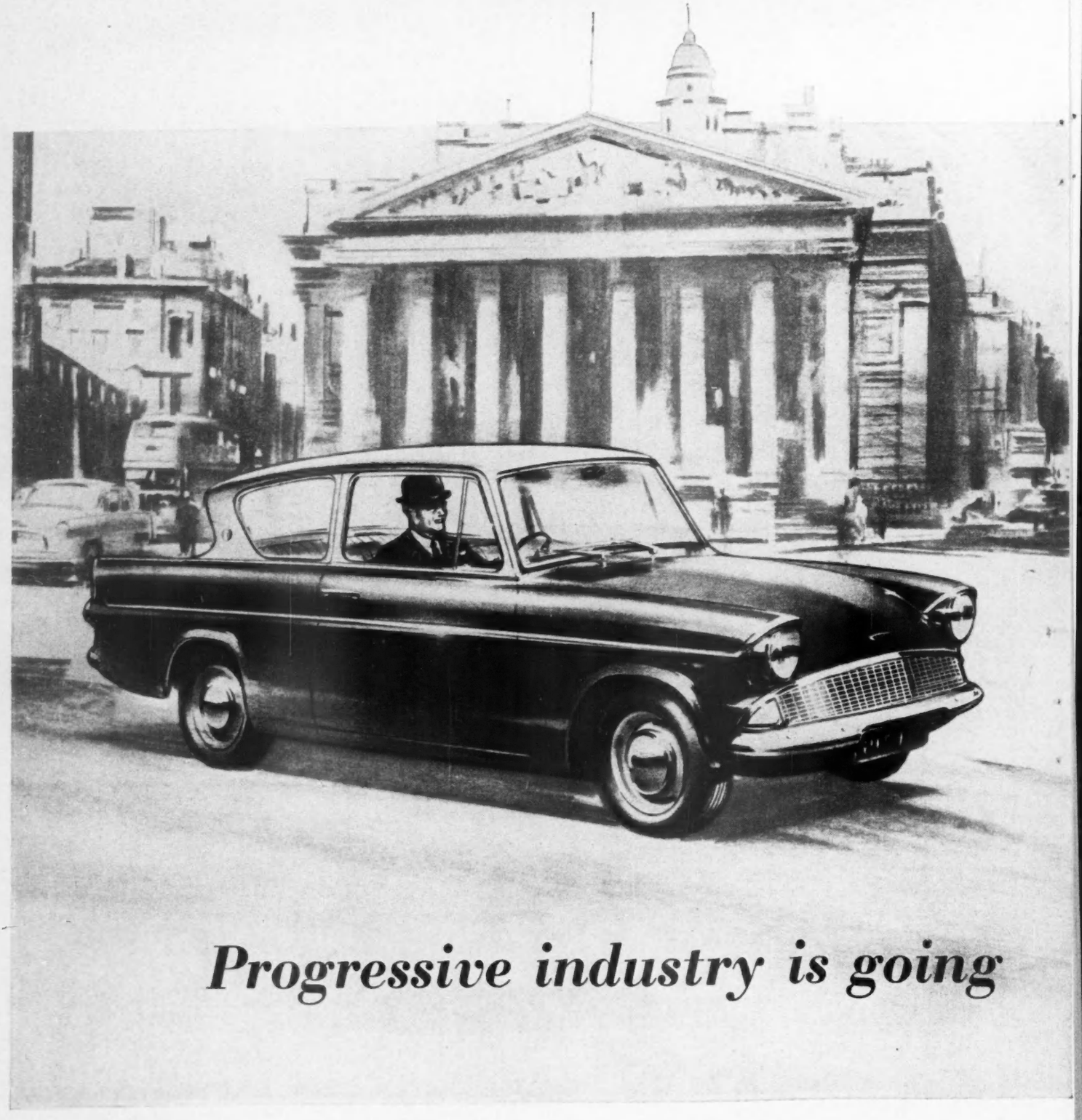
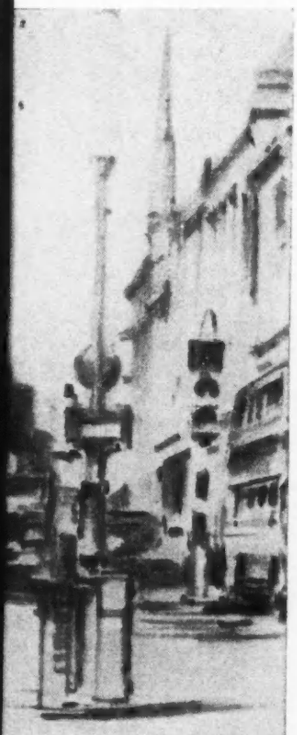
Every FORD



Progressive industry is going

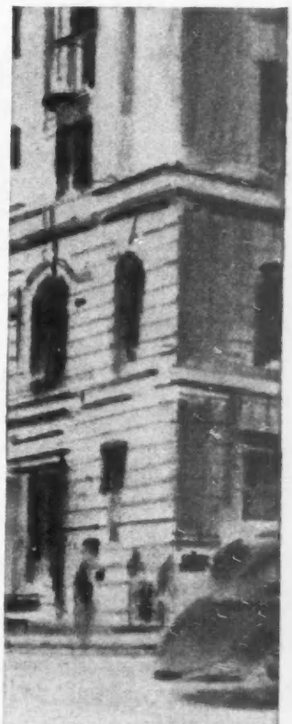
starts on Coal

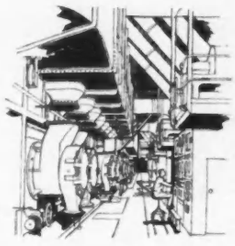


FIVE-STAR MOTORING—gleaming, colourful, swift and safe—begins at Dagenham, a giant factory that covers over 550 acres of a once desolate marsh. The judgment and business acumen of the men who have made Ford one of our great key industries is reflected in every operation in the factory, every decision in the boardroom.

In the impressive steam power plant that supplies the entire factory coal is the chosen fuel. Coal has been chosen because pulverised coal — fired in powder form — *gives accurately controlled heat with the lowest fuel bills.* Coal has the invaluable long-term advantage that it is a home-produced fuel which can supply all the fuel needs of British industry for decades to come.

If your voice is a deciding one in the choice of fuels for *your* factory, remember Ford. Beneath its smokeless chimneys is a wealth of knowledge and applied experience that is an invaluable example of hard thinking and wise decisions. Ford say *coal.* That's five-star wisdom.





Here are some key facts and figures about the Ford main power station

Number of boilers.....4 high-pressure water-tube boilers, with superheaters, airheaters and economisers
Steam pressure.....1,250 lbs. per sq. inch
Steam temperature.....940°F
Feed temperature.....380°F
Continuous maximum rating....1,000,000 lbs. of steam per hour (largest unit 400,000 lbs. per hour)
Method of firing.....Pulverised fuel
Fuel (for steam raising) 207,000 tons of coal a year
(for steel making) 342,000 tons of coal a year

ISSUED BY THE NATIONAL COAL BOARD

forward on COAL

See the modern mechanical coal-firing equipment on the N.C.B. stand No. 8F at the Fuel Efficiency Exhibition, Olympia, from April 27th to May 6th.

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GREY IRON

CASTINGS

ANY WEIGHT UP TO 100 TONS

SPHEROIDAL GRAPHITE CAST IRON UP TO 20 TONS
HEAT RESISTING AND PRESSURE CASTINGS A SPECIALITY

HARLAND & WOLFF LIMITED

CLYDE FOUNDRY, GOVAN, GLASGOW

TELEGRAMS: CLYFOUNDIC GLASGOW TELEPHONE GOVAN 2265

— ELEVANJA —

FLAMEPROOF SOLENOIDS

Groups I - II - III gases
Pull 3 to 285 inch. lbs.
Continuous rating

A.C. single phase
A.C. three phase
D.C. up to 600 volts

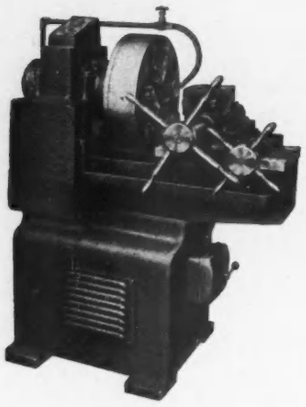
Suitable for operation in most hazardous & dusty atmospheres

ELLISTON, EVANS & JACKSON LTD
LONDON & BRIDGWATER

HEAP'S

PATENT SCREWING MACHINES

are made in all sizes suitable for all classes of work.



Bench Machines from ¼" to 4" capacity.

Floor Machines from ¼" to 8" capacity.

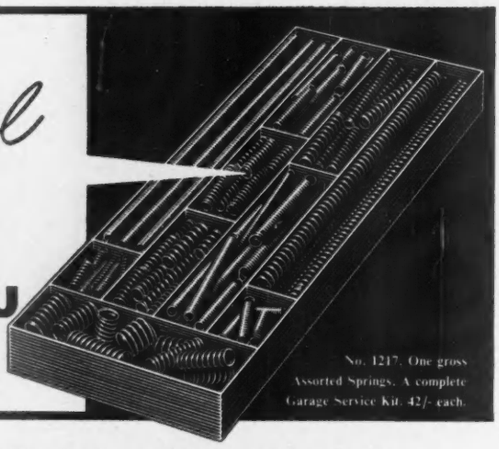
Pipe cutting Screwing Machines up to 12" capacity.

Bolt screwing and Nut tapping Machines up to 4" capacity.

We will gladly advise you as to the most suitable machine for your particular class of work.

JOSHUA HEAP & CO., LTD.
ASHTON - UNDER - LYNE · ENGLAND

THAT Experimental Spring YOU WANT IS WAITING FOR YOU IN THIS BOX ...



No. 1217. One gross Assorted Springs. A complete Garage Service Kit. 42/- each.

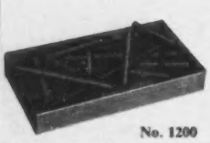
We know exactly how difficult it is to find springs for experimental work . . . we've been making quality springs for over 100 years. So, we confidently offer you our excellent range of small boxed assortments which covers a very wide range.

We can only show a few boxes. Send us a p.c. for our full list. If ever you are stuck with a spring problem let our Research Department put their long experience at your disposal.

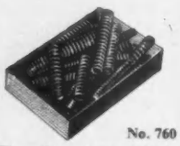
Have you a presswork problem?

If so, the help of our Design Staff is yours for the asking.

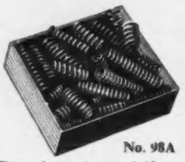
If not, try another box in the Terry Assorted Springs range



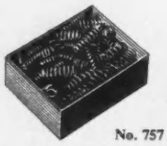
No. 1200
Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. 13/6.



No. 760
Three dozen Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6.



No. 98A
Three dozen Assorted 1" to 4" long, ¼" to ½" diam., 19G to 15G. 5/6.



No. 757
Extra Light Compression, 1 gross Assorted, ¼" to ⅜" diam., ½" to 2½" long, 27 to 19 S.W.G. 15/-.

No. 753
Three dozen Assorted Light Expansion ¼" to ½" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6.

No. 758
Fine Expansion Springs. 1 gross Assorted ¼" to ½" diam., ½" to 2" long, 27 to 20 S.W.G. 15/-.

Cut production costs with Terry's Wire Circlips. We can supply immediately from stock — from ⅛" to ½".

Looking for good Hose-Clips? Send for a Sample of Terry's Security Worm Drive Hose Clip and price list.

TERRY'S for SPRINGS

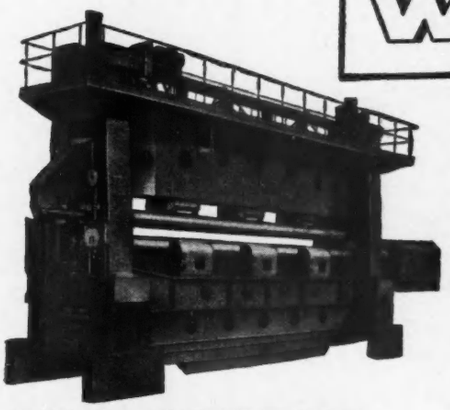
Really Interested in Springs?
"Spring Design and Calculations" 9th Edition tells all — post free 12/6.

HERBERT TERRY & SONS LTD
Redditch, Worcs.
(Makers of Quality Springs, Wireforms and Presswork for over 100 years)

HT30E

modern shipbuilding equipment by

WAGNER OF DORTMUND



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SHIP & MARINE ENGINE BUILDING MACHINES

SHIP PLATE BENDING MACHINES
with or without pre-bending.

HYDRAULIC BENDING MACHINES
from 160 tons.

THREE-ROLL BENDING MACHINES
with or without pre-bending.

FOUR-ROLL BENDING MACHINES
for plates from $\frac{3}{4}$in. thick.

SHIP RIB BENDING MACHINES
for sections up to 16in. deep.

ROLLER SECTION BENDING MACHINES
with or without pre-bending.

INTERNATIONAL MACHINE TOOL EXHIBITION 1960
June 28-July 6 Olympia-London
STAND No. 64 GRAND HALL

Please let us demonstrate to you.

PLATE STRAIGHTENING MACHINES
for plates from $\frac{3}{4}$in. thick.

DOUBLE STANDARD PLATE SHEARS
for plates from $\frac{3}{4}$in. thick.

CIRCULAR CUTTER SHEARS
for plates from $\frac{3}{4}$in. thick.

CIRCULAR CUTTER TRIMMING SHEARS
for trimming both sides and slitting plates from $\frac{3}{4}$in. thick.

ROLL SHEARS
also with planing attachment for plates $\frac{3}{4}$in. thick.

PLATE EDGE PLANING MACHINES
with rack or screw drive, cutting power from 1·2 tons.

PUNCHING MACHINES
from 160 tons.

LEVER PUNCHING MACHINES AND SHEARS
single and combined, from 160 tons.

WATER HYDRAULIC AND OIL HYDRAULIC SHIPBUILDING PRESSES
from 160 tons.

OIL HYDRAULIC STRAIGHTENING AND BENDING PRESSES
from 125 tons.

MECHANICAL STRAIGHTENING AND BENDING PRESSES
from 200 tons.

HYDRAULIC PRESS BRAKES
from 160 tons.

MECHANICAL PRESS BRAKES
from 200 tons.

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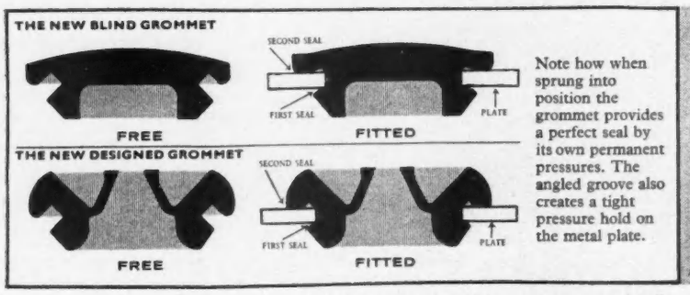
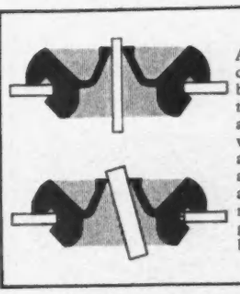


Note how when sprung into position the grommet provides a perfect seal by its own permanent pressures. The angled groove also creates a tight pressure hold on the metal plate.



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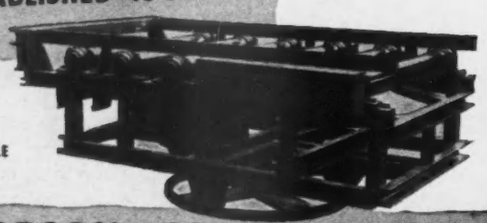

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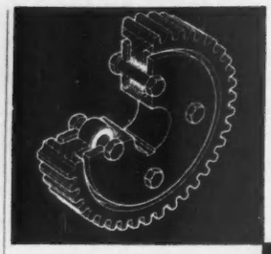

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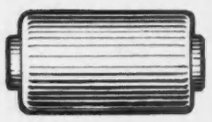

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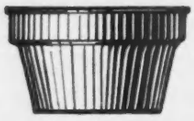

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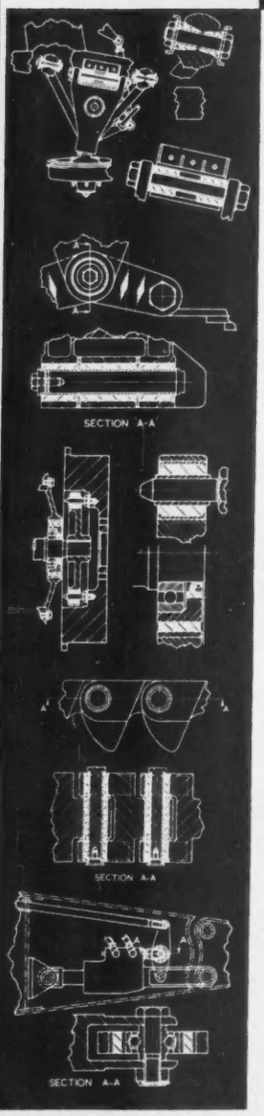

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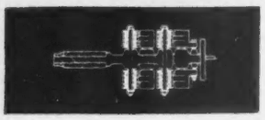

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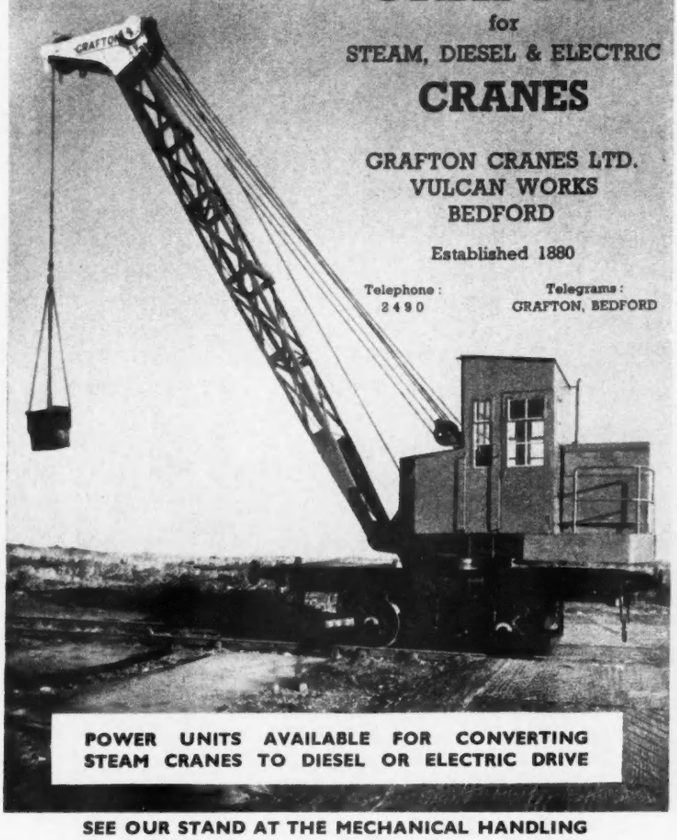

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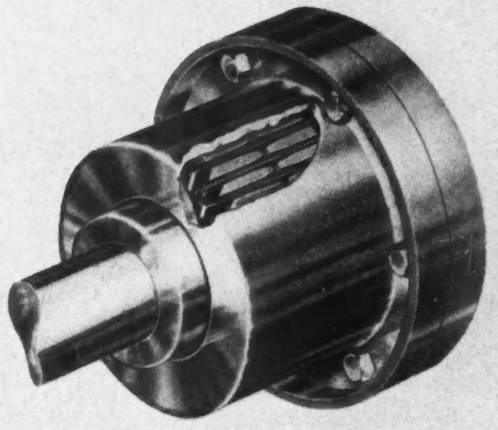

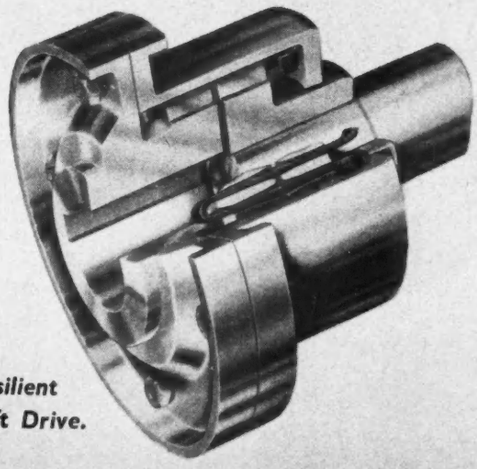

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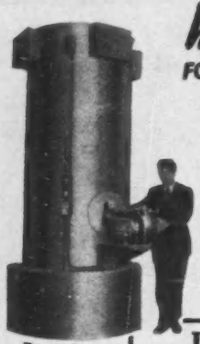

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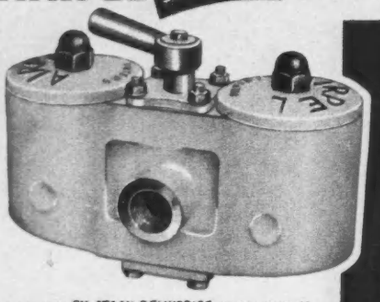

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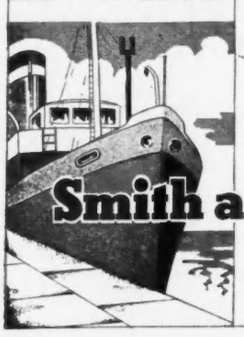

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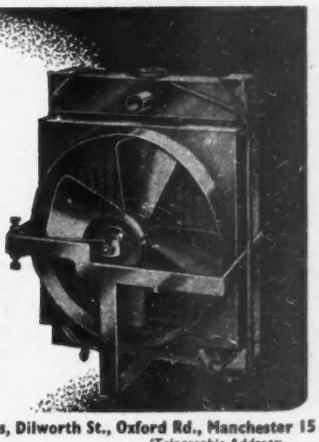

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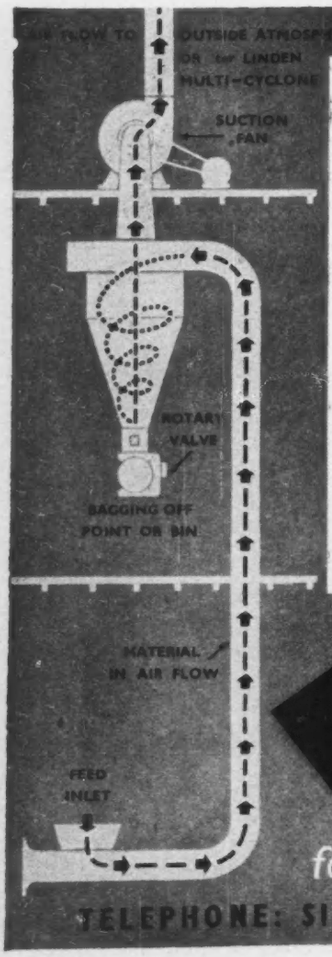

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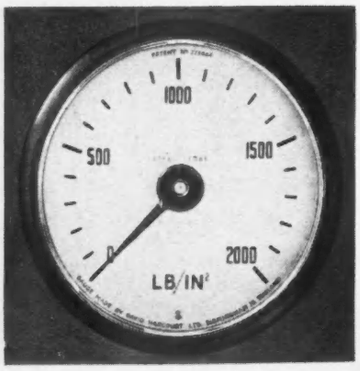

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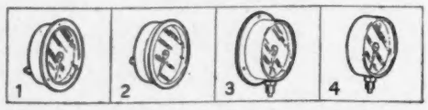

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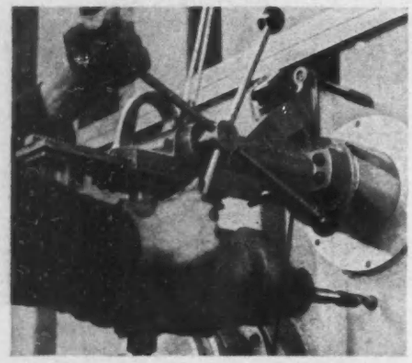

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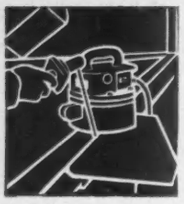

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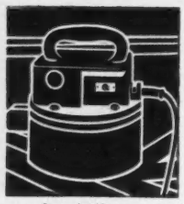

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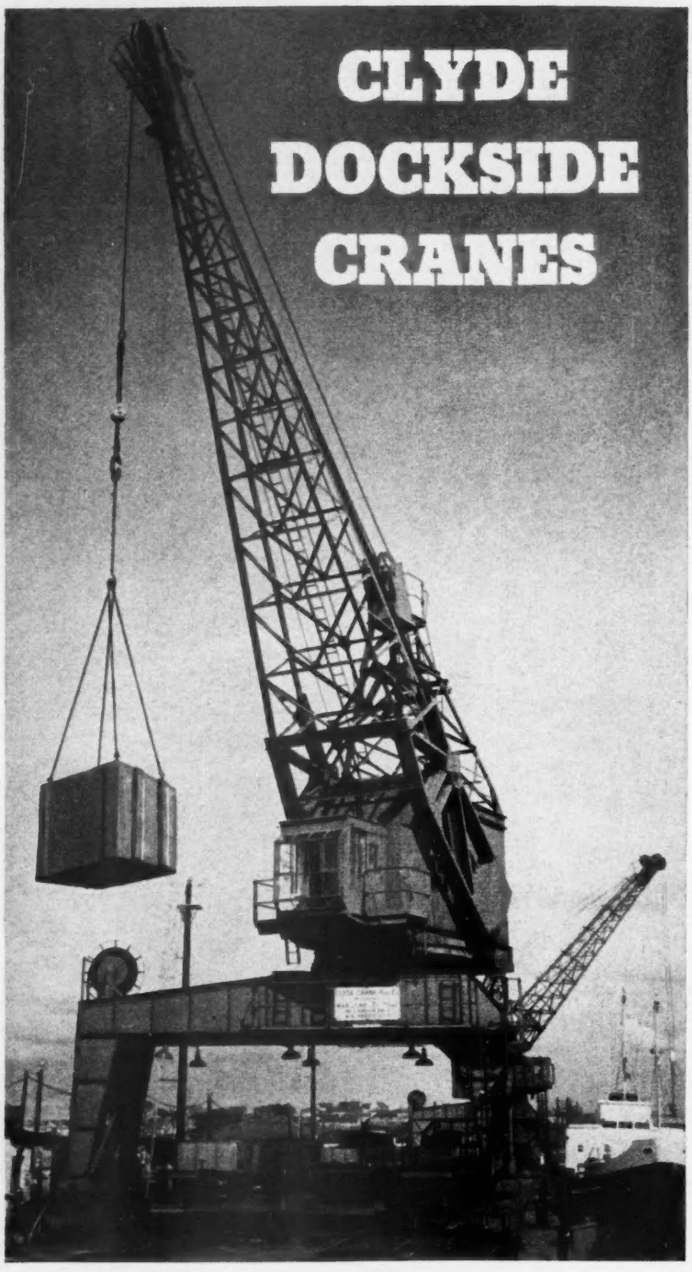

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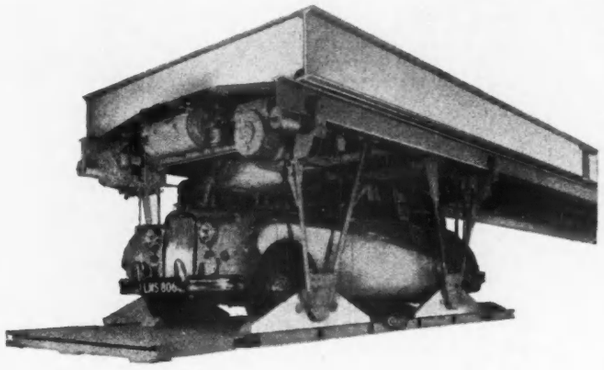

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1⅛ in. dia.	Oil quenched 780° C.	72·0	19	69
2⅛ in. dia.	Oil quenched 860° C.	62·7	19	67
3 in. dia.	Oil quenched 780° C. Oil quenched 860° C. Oil quenched 780° C.	59·7	22	72

The benefits to be gained from the more highly alloyed case-hardening nickel steels, such as EN 33; EN 34; EN 36 and EN 39 include ease of heat treatment, minimisation of processing distortion, higher load-carrying capacity, and general reliability.

Send for 'The Mechanical Properties of Nickel Alloy Steels' ▶

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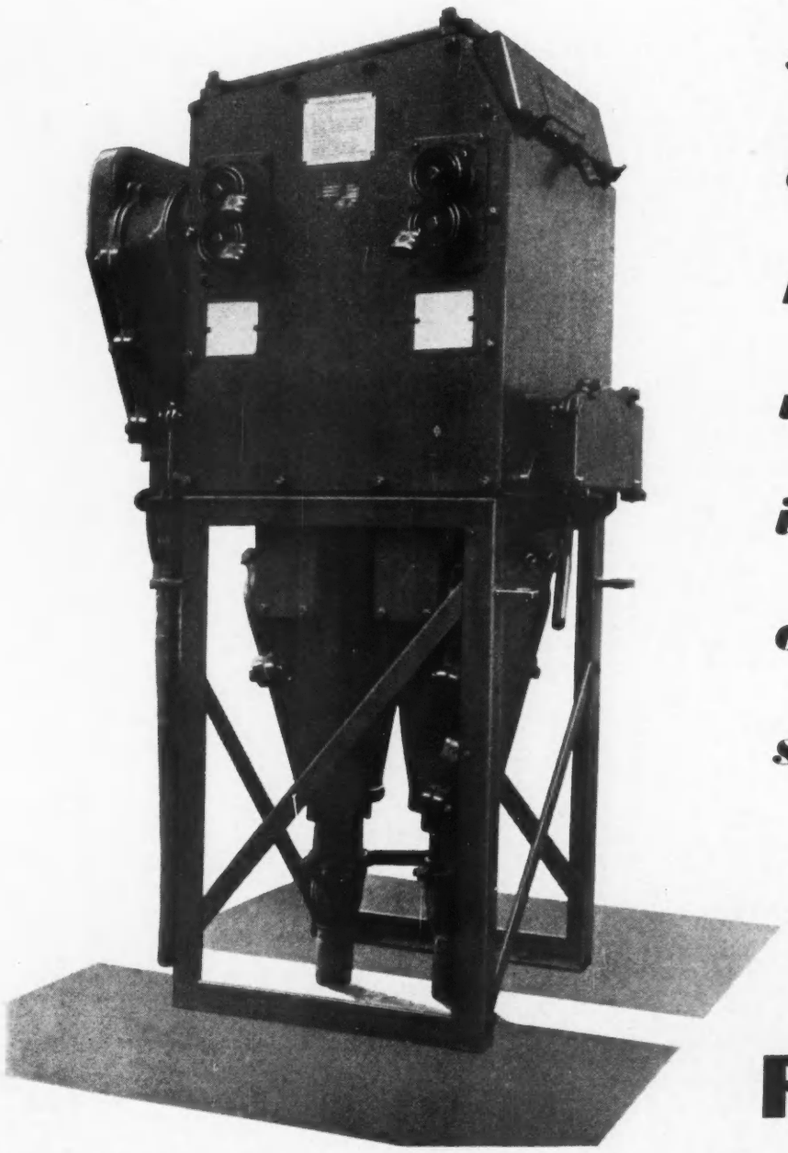
TGA 21/25

Class-J switchgear consists of type-JS single-switch, type-JSS double-switch, and type-JK fuse-switch units together with type-JKSS ring-main units which combine two switches and one fuse-switch

Up to 11 kV



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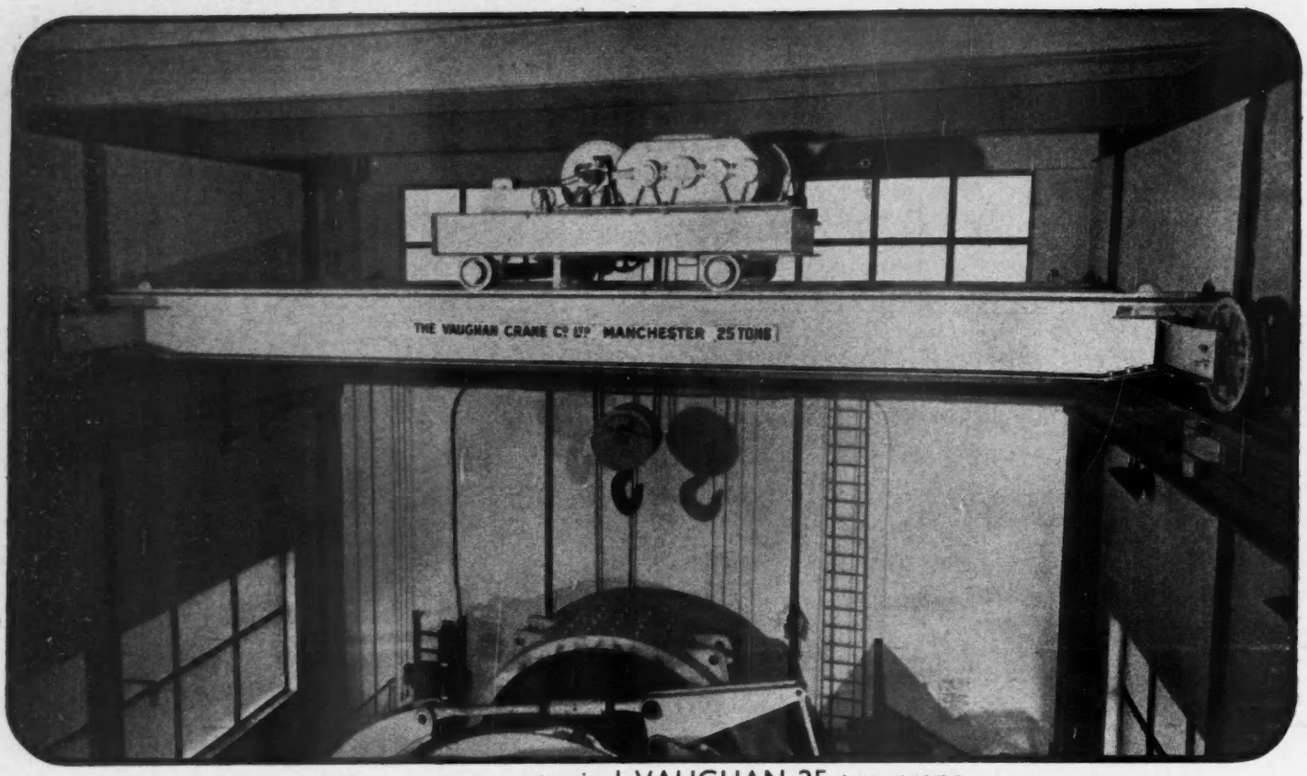

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18
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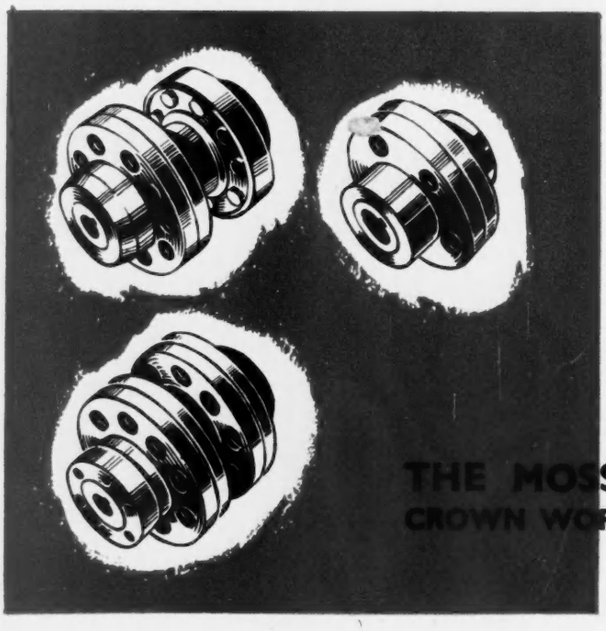

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